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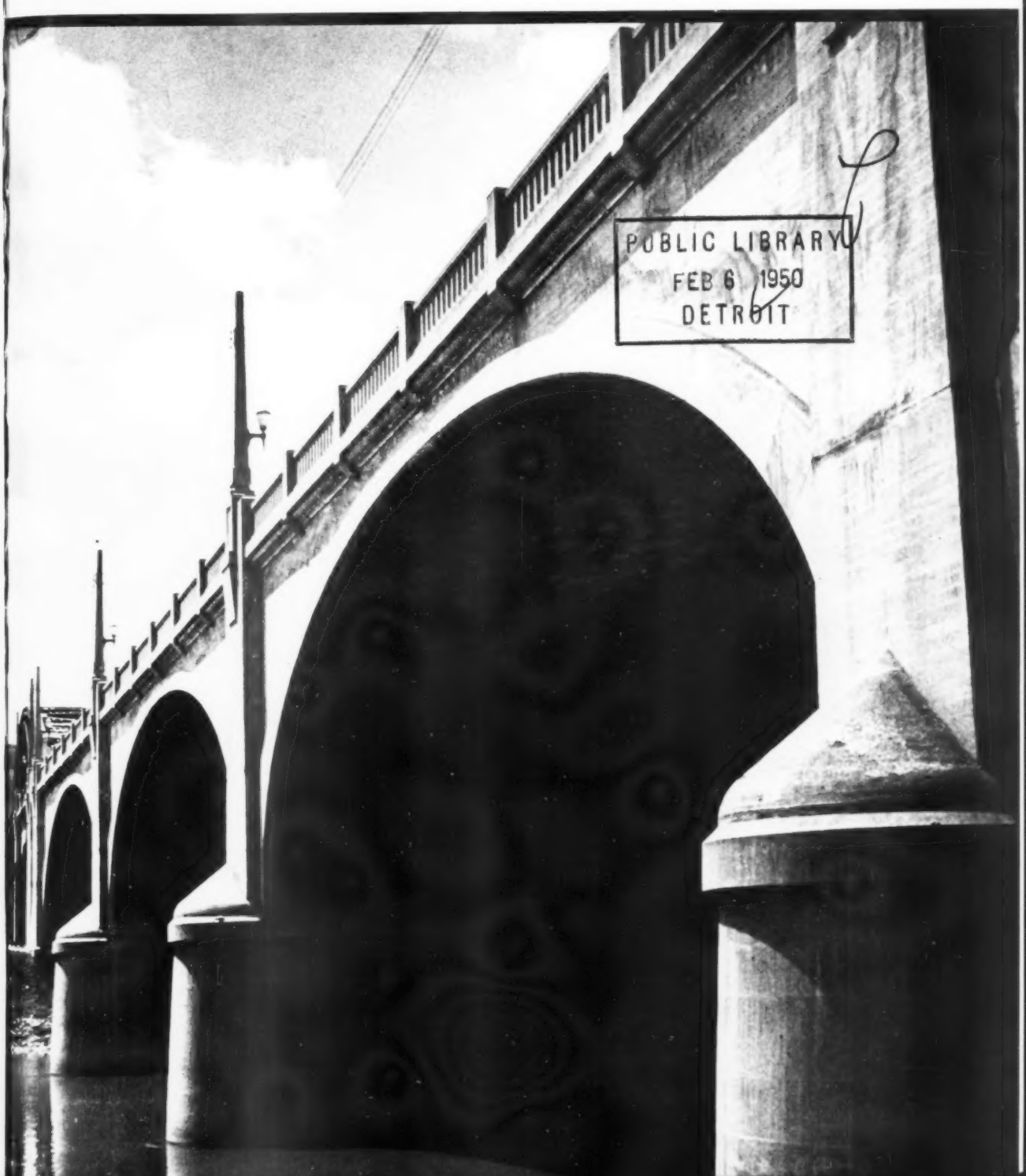
TECHNOLOGY REVIEW

February 1950



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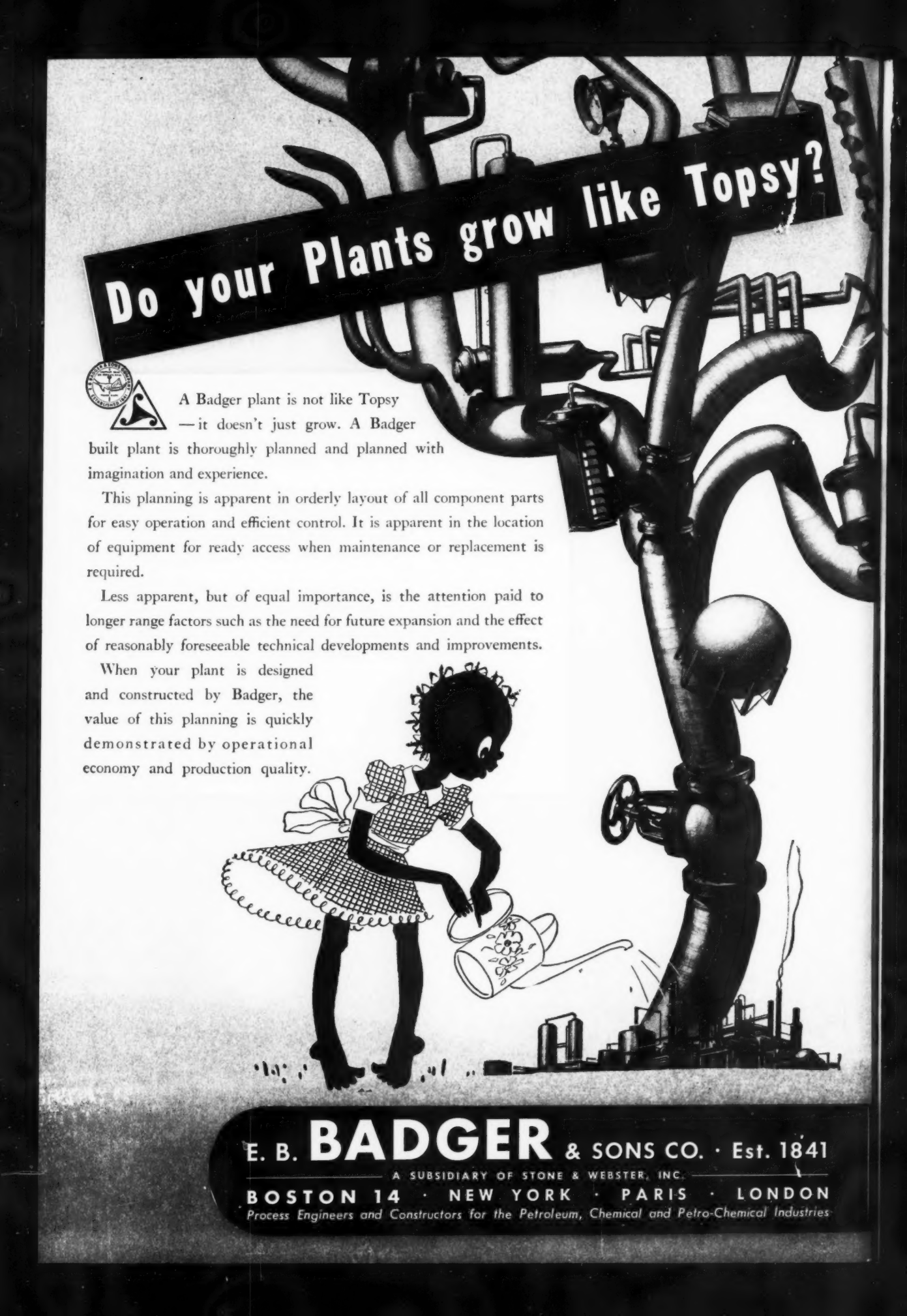
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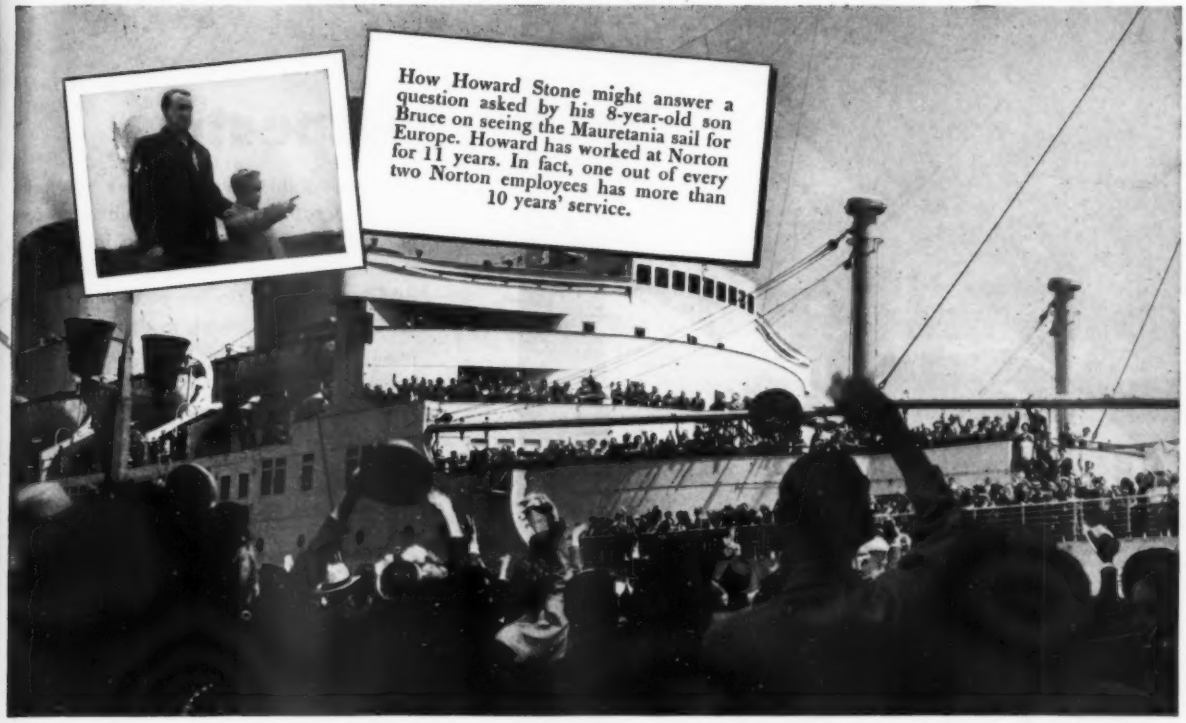

How Howard Stone might answer a question asked by his 8-year-old son Bruce on seeing the Mauretania sail for Europe. Howard has worked at Norton for 11 years. In fact, one out of every two Norton employees has more than 10 years' service.

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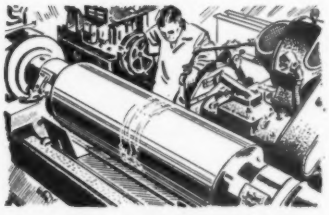

"Things like the ship's steel plates. They must be just right. That's why the powerful rolls that form them in steel mills are kept smooth and true with big Norton roll grinders and fast-cutting Norton grinding wheels.

"To give today's floating cities extra speed and smoother sailing, propellers must have perfect surfaces... the kind that come from rough-grinding with Norton cup-shaped wheels and finishing with Behr-Manning abrasive discs.

"Yes, and attention to fine details is the sign of the wise ship designer. That's why the terrazzo floors in galleys of ships like the 'Queen Mary' get lasting, non-slip safety from a Norton product called Alundum aggregate."

"So, you see, Bruce, in these ways and many more Norton has a hand in making modern ships bigger and better... another proof that I'm not boasting when I say 'Norton makes better products to make other products better'."

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perspective

Perspective in plant design and engineering calls for matching progressive engineering with economic foresight. We cannot predict the future, but we can recognize that the economic balance for a plant or process never stays put. We in Lummus do our best to look at your plans from past, present and future points of view. Our perspective has paid off in plants of exceptional operating flexibility able to make a profit in spite of wide swings in demand.

perspective

In planning this French refinery, both its initial operating level and its ultimate, expanded capacity were guiding factors for design. Room was provided for the easy addition of filters, double pipe chillers and refrigeration equipment, to double the capacity of the unit in this respect. An efficient plant today, it will be equally efficient tomorrow, because expansion need never be "makeshift."

perspective

Lummus catalytic cracking plants, war-built for 100-octane gasoline, are being operated to produce motor gasoline of lower octane rating on a consistent low-cost basis. Their suitability for this latter service was attained without any compromise in design for their original purpose. Rather, the Lummus-engineered design had the flexibility to meet requirements for the efficient production of either fuel.

perspective

The interest of Lummus in any of its installations does not end with construction and initial operation for customer acceptance. Periodic visits by Lummus field representatives are continued to review performance. In a recent case where a radical change in product requirements arose, these operating checkups furnished valuable aid in arriving at a prompt and practical plant modification to meet the new demands.

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THE TABULAR VIEW

War's Weapons. – In the flush of forthcoming victory, during the early half of 1945, enthusiasm ran high that the end of World War II would bring about conditions propitious to the formation of a truly unified "one" world. The need for international unity was dramatically foreshadowed before a small group of scientists on the white sands of Los Alamos in July, 1945, and the public was initiated into the need for a new kind of international thinking by subsequent events in Nagasaki and Hiroshima. As the Iron Curtain descended and divided the world into two antagonistic camps in a cold war, new reasons were found for pursuing the search for world unity and responsible international agreements. The search is still going on and many able minds make their contribution toward this desirable objective. One such attempt is contained (page 203) in "The Weapon of the Next War" by M. H. WILLIAMS who prefers to be known merely as a "student of geopolitics, teacher, writer, and veteran of World War II." The first of this two-part article discusses the characteristics of some modern instruments of war. The second part, to appear in the March issue, examines the probable nature of a future war.

Wholesome World. – The search for the wholesome world is likewise sought by M. F. ASHLEY MONTAGU, Head of the Department of Anthropology at Rutgers University, and formerly a member of the faculty of the Hahnemann Medical College and Hospital of Philadelphia. His article in this issue, "Living in an Atom-Bomb World" (page 205), is primarily a plea for unified and responsible world government, which Dr. Montagu sees as the only solution to the world's present ills. Although addressed primarily to members of our Western civilization – because they are within range of a free press – Dr. Montagu's admonitions apply with equal force to the "democracies" of force, concentration camps, and police states. A keen student of mankind and his ethics, or lack of ethics, Dr. Montagu is particularly well qualified to deal with the topic in this issue. His past achievements include the making of the film *One World or None* for the National Committee on Atomic Information which has been described as the "most effective documentary ever made."

Watery Wharf. – "The Delayed Invention" by WILLY LEY (page 207) is a rather unusual story which brings into sharp focus the turn of events which may be expected to come about occasionally in a rapidly growing field of technology. Underlying Mr. Ley's story is a valuable lesson in economics as related to technological progress, for the transoceanic islands originally proposed to facilitate long-distance flying were made obsolete by rapid progress in aeronautics. As one of its editorial associates, Mr. Ley is a frequent contributor to The Review. In the general area of New York City, he is also in demand as a lecturer on rockets and related problems. Of several books to his credit, the latest is *The Conquest of Space.*

Thinking of improving

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MAIL RETURNS

Mathematical Myopia

FROM GEORGE D. ATWOOD, '00:

While reading an interesting article on the conservation of minerals in the January, 1950, issue of The Review, I was surprised at the statement that the year 1950 was the beginning of the sixth decade of the Twentieth Century. Had this been written by a Harvard man, I might understand his mental confusion, but appearing in an official publication of M.I.T., it is, to say the least, discouraging.

Perhaps we should have fifth-grade arithmetic as a requirement for entrance examinations, or possibly some of your editorial staff should be informed that the first year of a decade is one and the last year of a decade is 10. Of course, I am too old to know — perhaps you have a new numerical system since my last days at M.I.T. in 1900.
Brooklyn, N.Y.

[Mr. Atwood undoubtedly refers to the opening sentence on page 156 in the article "The Twentieth Century Mid-Point" where reference is made to the earth swinging "into the orbit that will mark the first year of the sixth decade of the Twentieth Century . . ." We wish we had made a qualifying statement (as did some other publications) that the end of 1950, rather than the beginning, marks the mid-point of our century, and the beginning of the sixth decade. We should like to be able to pass off this slip onto our printer, The Hildreth Press, Inc., who has just gone through the pains of moving from Brattleboro, Vt., to Bristol, Conn. But honesty compels us, with a red face, to embrace this oversight as our very own. — Ed.]

Congratulations for Camerists

FROM CLINTON C. KEMP, '43:

I find the articles in The Review very interesting indeed, and also feel like commending you frequently on the photographs included with them. However, I think you deserve very special congratulations for the three pictures illustrating the article on gossip in the December, 1949, issue. They are first rate!
Hamilton, Ohio

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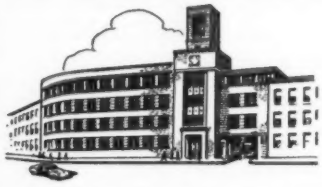

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This process is of particular significance to the steel industry today. Why? Because government surveys show that America's reserves of top-grade iron ore—source of steel—are fast being reduced. But there remain almost inexhaustible beds of the once scorned low-grade iron ore called *taconite.*

The extremely hard and dense nature of taconite makes usual mining methods too costly and impractical. But the jet-piercing process—*with 1/10 the equipment and at a reasonable cost*—will burn holes straight into the solid taconite so that it can be blasted into lumps of usable size.

Also, destructive abrasion from the sharp-edged rock on loading and crushing equipment is being better controlled by machine parts made from extra-hard alloy steels. And to concentrate the iron content of the ore, new chemical processes can flush away much of the "waste" matter—thus leaving an ore 30% richer, for more efficient smelting.

The people of Union Carbide created the jet-piercing flame process as well as many of the alloys, chemicals, and other materials essential to today's mining efficiency. And UCC stands ready to help solve problems in other fields of American enterprise . . . wherever better basic materials and better processes are needed.

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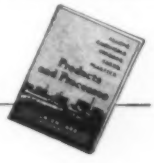

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Me!... a V.P. at 33

because I said "TAKE IT TO TAFT-PEIRCE"

" . . . but I can't touch that retooling for six months," I said.

"Why not?" The Old Man's tone was ominously silky.

"Well . . . there's the Charlesville project, Bill Newton's job and . . . "

Majestically the Boss started to rear all five feet of him into Napoleonic stance number one.

"Here it comes," I thought. "Trouble with a capital T." Then, just in time, I had an inspiration.

"Let's Take It To Taft-Peirce," I almost shouted.

That did it. He stopped . . . beamed. And now I'm a V. P.

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What GENERAL ELECTRIC People Are Saying

E. E. CHARLTON,

Research Laboratory

MEDICAL ELECTRONICS: In medical x-ray diagnosis we have, in the last few years, seen the use of the fluoroscope decrease in comparison with the radiography. Why has this been? The reason is twofold. The patient and the doctor were both subjected to so much radiation that the hazards of radiation damage imposed severe limitations on adequate and flexible fluoroscopic techniques. Furthermore, these hazards imposed the use of low x-ray intensities yielding screen images of such low luminosity that the limitations of the human eye precluded high resolution; that is, the recognition of fine detail. The enforced requirement of low x-ray intensity also brings with it the necessity of a 15- or 20-minute period for dark adaptation of the eyes in preparation for the fluoroscopic examination. The doctor must also limit his examination to brief glimpses rather than a more detailed study of the screen image. If the required x-ray intensities for examination could be reduced and the fluoroscopic picture sufficiently increased in brilliance, these limitations would be largely dissipated.

It seems certain that electronics will come to the rescue in this problem by removing many and perhaps all of these limitations. Of various systems that have been proposed and are being investigated, one that holds great promise makes use of some form of electron image tube and embodies some of the principles of the wartime sniperscope, by which our soldiers were enabled to see the enemy in the dark . . . Such an x-ray image tube intensifier offers the possibility of an amplification of as much as several hundred fold in brightness while at the same time increasing resolution. Successful attainment of this goal will not only greatly enhance the usefulness of the fluoroscopic method but will also facilitate photographic recording of the image, especially in those cases where moving pictures are desired. A full realization of all that the method promises would be quite revolutionary in the x-ray art.

Inter-American Congress of Surgery, Chicago, October 21, 1949

A. H. TAYLOR,

Lighting Research Laboratory

MOLD CONTROL: Every housewife has experienced the loss of foodstuffs by reason of molds. Likewise, manufacturers of many products incur losses produced by mold contamination at some point in the manufacturing process. In total these losses amount to millions of dollars yearly; consequently, any practical method of reducing losses due to molds should be of great general interest.

Air-borne mold spores, originating in decaying animal and vegetable matter, are more widely distributed in outdoor and indoor air than is generally recognized . . .

It has long been known that bacteria could be killed by suitable exposures to ultraviolet, but little was known regarding its effect upon air-borne mold spores. The introduction of germicidal lamps . . . made it feasible to apply them to the disinfection of air, some liquids, and the surfaces of solids. Researches . . . have shown that the mold spores can also be inactivated by the germicidal ultraviolet energy, but that the required dosages are much higher than for most bacteria . . .

Although mold spores are much more resistant to germicidal ultraviolet than are the mixed organisms in saliva, . . . it should be possible to reduce economic losses due to mold contamination—especially during manufacturing processes—by practicable installations of germicidal lamps. Furthermore, they can be applied to upper-air irradiation of occupied rooms without exceeding intensities safe for the occupants of the rooms. Thus personnel and product protection can be promoted simultaneously with the same installation of germicidal lamps. Applications of localized high-intensity radiation over production lines, such as bottling or canning, are being used with good results in many places. While it is unreasonable to expect the germicidal lamps to completely eliminate economic losses due to molds, such losses can be materially reduced.

American Public Health Assn., New York City, October 28, 1949

★

K. E. WAKEFIELD,

General Engineering & Consulting Laboratory

MAGNETIC CLUTCH: Much interest has been evidenced in the National Bureau of Standards' recent report that so-called "magnetic" fluids, consisting of finely divided iron powder mixed with light oil, can be utilized with great efficiency as a medium for binding together two parallel surfaces between which a magnetic field has been produced. Such an arrangement can be readily set up in the form of a clutch and, because of this, the mechanism became known as the "magnetic fluid clutch." . . .

The magnetic fluid clutch consists primarily of two parallel magnetic surfaces separated by a small gap that is filled with a mixture of oil and finely divided iron powder. The surfaces may be two parallel disks or concentric cylinders, each rotating independently of the other about a common axis. The unit contains a coil to produce magnetic flux in the region between the surfaces, and a return path for the flux is provided. Provision is also made to seal in the iron-oil mixture to prevent leakage.

If no magnetic field is present, the force restraining relative motion between the two surfaces is produced only by the viscous drag. In the presence of a magnetic field, however, the fluid seemingly solidifies and the restraining force becomes very great. Thus the device adapts itself well to a clutching or braking operation.

General Electric Review, December, 1949

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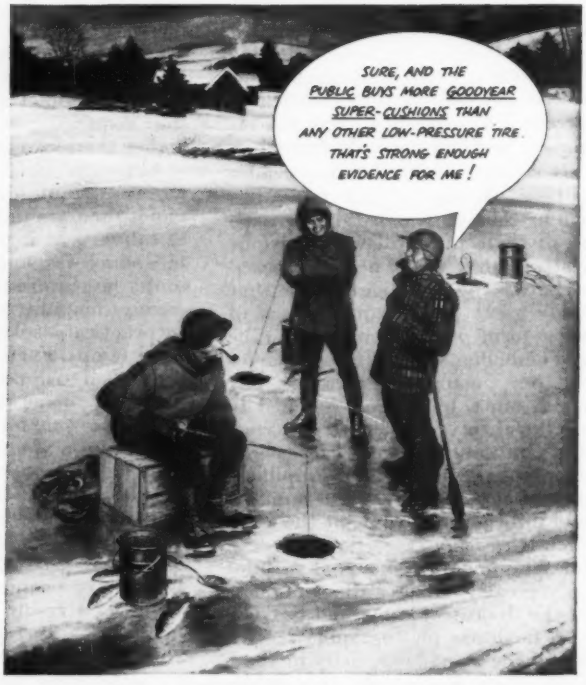
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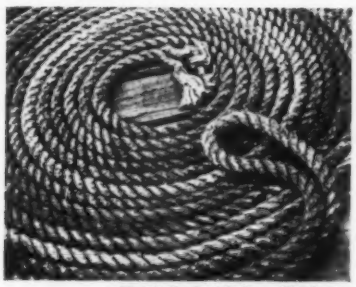

Nettie L. Smith from Black Star

THE TECHNOLOGY REVIEW

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EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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Publisher: H. E. LOBDELL

Published monthly from November to July inclusive on the twenty-seventh of the month preceding the date of issue, at 50 cents a copy. Annual subscription, $3.50; Canadian and foreign subscription, $4.00. Published for the Alumni Association of the M.I.T.: C. Adrian Sawyer, Jr., President; H. E. Lobdell, Executive Vice-president; Orville B. Denison, Horatio L. Bond, Vice-presidents; Donald P. Severance, Secretary-Treasurer. Published at Hildreth Press, Inc., Bristol, Conn. Editorial Office, Room 1-281, Massachusetts Institute of Technology, Cambridge 39, Mass. Entered as second-class mail matter at the Post Office at Bristol, Conn. Copyright, 1950, by the Alumni Association of the Massachusetts Institute of Technology. Three weeks must be allowed to effect change of address, for which both old and new addresses should be given.

K. H. Strelow from Black Star

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H. Armstrong Roberts

Timber!

The population of the United States has increased 75 per cent during the past four and a half decades, and our material acquisitions have multiplied in the interim. Yet, lumber production, which reached its peak of 46,000,000,000 board feet in 1906–1907, dropped to an annual average of about 31,000,000,000 board feet in the 1935–1945 decade. The more efficient use of forest products (in which plywood and similar laminated materials replace solid woods, and in which pulp products compete with sawn lumber and wood in natural form) has aided in conserving an important national resource. The rise of plastics and the substitution of metals have also contributed to this trend; and losses from forest fires have taken a dip in recent years. But lumbering of today, with its mechanization, as shown in these views from Washington and Northern Ontario, is enjoying a postwar boom.

THE
TECHNOLOGY REVIEW

Vol. 52, No. 4 February, 1950

The Trend of Affairs

Studying the Weather with Radar

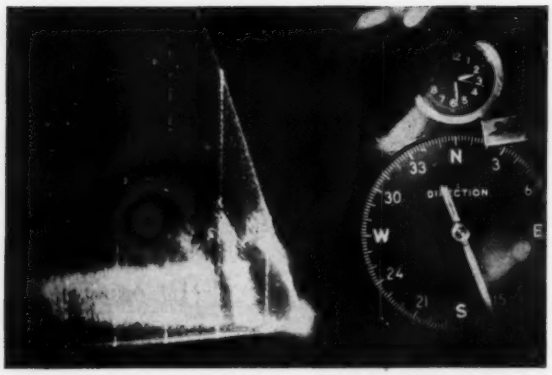
MICROWAVE radar is being developed in the Department of Meteorology as a new tool for tracking and studying the detailed behavior of storms. With the new technique, the location and path of areas of precipitation can be determined. In addition, the local variations in intensity of precipitation and the internal movements within the storm area may be estimated. Within the foreseeable future, the new tool holds promise of enabling aircraft traffic towers to employ their present radar sets for local storm observations and, thereby, to assist planes in avoiding turbulences, icing, and other unfavorable weather conditions. Although of less immediate application, the knowledge which is gained from radar storm tracking finds extensive use in supplementing other weather data so that long-range weather forecasts may be brought one step closer to realization.

Weather radar is a postwar research project which owes its origin to the intense development of military radar techniques during World War II. Early in this development, it was found that the high-power, very short wave pulses sent out from a radar transmitter were reflected and returned to the radar receiver by areas of precipitation; but thorough exploitation of this discovery had to await the completion of the war. The program under way at M.I.T. was initiated early in 1946 through a contract placed by the Army Signal Corps with M.I.T.

Prior to the use of radar, the meteorologist had no way of obtaining an instantaneous picture of a storm over a large area. If there were numerous observation posts simultaneously taking data throughout a storm, it would be possible to reconstruct detailed pictures of the disturbance; but even with a prohibitively large number of such observation posts, details would be missed which are picked up and presented instantaneously by radar. The entire atmosphere is now scanned for a radius of over 100 miles, and all regions of precipitation throughout this area are indicated on the screen of an oscilloscope.

The principle of the scheme is that water droplets and ice particles cause backscattering of radio energy in the three- to 10-centimeter wave length range. The intensity of the backscattering is proportional to the sixth power of the drop diameter. Very small drops scatter a negligible amount of the radar beam, and it happens that the intensity of scattering first becomes measurable as the drops reach a size about large enough to start falling. Clouds, therefore, are detected only at very short ranges. The intensity of the precipitation echo signals depends both on the size and number of the drops, as well as their distance from the observation post; therefore, a given pattern on the radar oscilloscope might be produced by different combinations of numbers and sizes of drops at different distances. Actually, the following three types of measurements are obtained: (1) the geographical location in space of the echoes, and their vertical extent, (2) the average intensity of the echo from any chosen region, and (3) the fluctuations in intensity of the echo from any chosen region which are functions of the velocities of the rain drops. Such data must be interpreted in meteorological terms.

The research group in the Department of Meteorology, working under the direction of Alan C. Bemis, '30, research associate, have three radar units, all of which are operated during any storms in the neighborhood of Cambridge. Two of the sets operate at three centimeters wave length, and the third at 10 centimeters. One of the three-centimeter sets is a new one having a narrow conical beam producing images of sharp definition. It was designed especially for weather studies by the Army Signal Corps. The other two are essentially World War II military sets.



Photographic reproduction of image on range-height indicator radar scope, showing a vertical section through a storm running for 60 miles southeasterly from M.I.T. The horizontal stratification occurs just below the freezing level.

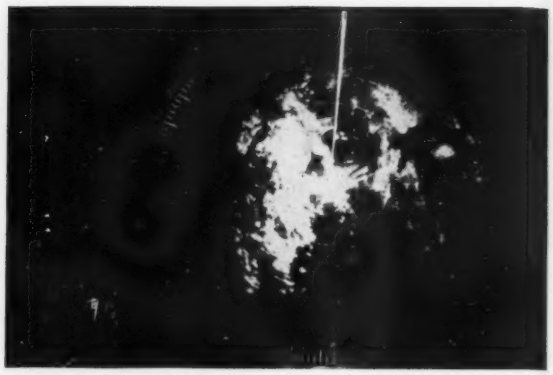


Image as seen on a plan-position indicator radar scope, showing widespread rain echoes extending over an area more than 200 miles in diameter. Some of the small intense spots are echoes from airplanes.

To date, these sets have been employed primarily in an analysis of the meteorological meaning of the radar scope pictures. During a storm, an airplane is flown through those regions of precipitation which appear on the radar scope. The plane collects data on the local values of the total liquid water content per unit volume, the size distribution of the rain drops or ice particles, the shape of ice particles, and the relative motion of the particles. This latter can only be estimated indirectly from the vertical accelerations of the airplane. The position of the airplane is followed by radar tracking, and accurate radar measurements of the storm near the plane are taken simultaneously with those using instruments in the plane.

In recent months, the analysis has been greatly expedited by the perfection of an instrument capable of measuring the size of rain drops from an airplane. In this instrument, individual water particles intercept a very narrow light beam which is directed at a photoelectric cell. The larger the particle, the greater will be the fraction of the light that is intercepted. Hence, the size of each water particle is transformed into an electric pulse each of which can be measured and counted automatically.

In addition to improving the interpretation of radar data, the meteorology group is already applying the method to investigating storm structure. Permanent radar records have been made of nearly all of the storms passing through the Cambridge area in the past two years. One particularly interesting observation is the location of the freezing level in the atmosphere, illustrated in the photograph at the left of the page. This picture results from a vertical sweep of the radar beam. The bright horizontal band represents the region where snow is melting to rain since liquid water is more strongly reflecting than snow.

Another interesting observation is shown in the photograph at the right where the radar beam is rotated in a horizontal plane. In this case, although the storm may appear to an observer at any one spot as a general steady rain, the radar screen shows it to have a complicated structure of intense and light precipitation zones. The course of the plane investigating precipitation characteristics of such zones can be readily traced on the display of the radar scope.

New Synthesis of Peptides

PEPTIDES, in the form of their more complicated protein cousins, constitute the principal components in skin, hair, horn, and other biological tissues. In the body, peptides are made naturally under simple, normal conditions, at low (body) temperatures, in aqueous solutions, and without harsh chemical reagents. In the past, chemists have been able to prepare peptides by methods involving elevated temperatures, nonaqueous solvents, and corrosive substances; but until recently, they have not been able to approach nature's method of achieving the same result. In the last eight years, a theory has been worked out to explain nature's method of preparing peptides. Recent studies, conducted at the Institute's Department of Chemistry, represent a preliminary attempt to duplicate this method of preparation.

The chemical combination of amino acids has its own value as a mode of peptide production, but, probably more important, the reactions themselves provide penetrating insight into protein chemistry. Knowledge of protein structure gained through the synthesis and study of relatively simple peptides has contributed enormously to a better understanding of the chemical nature of toxins, antibodies, hormones, enzymes, and viruses. With the recent discoveries of the peptide nature of certain antibiotic substances, including gramicidin, tyrocidin, and diplococcin, there is renewed interest in practical methods for the synthesis of peptides.

An interesting approach has been made to the duplication of nature's own way of synthesizing peptides, which, like their more complex relatives, the proteins, are composed of repeating amino acid structural units. Although chemical methods are known for joining together amino acid molecules to form simple peptides, none of these resemble the route used in living cells. According to currently accepted theory, the natural synthesis of peptides proceeds by an activation of the amino acid carboxyl group by combination with phosphoric acid.

In a forthcoming issue of the *Journal of the American Chemical Society,* John C. Sheehan and Victor S. Frank, '42, describe the first successful preparation of peptides using synthetic, energy-rich, phos-

phorylated amino acid derivatives. The reactions were carried out at room temperature, in neutral aqueous solution, thus simulating physiological conditions. During the past year, the same persons developed a second promising new technique for preparing peptides as reported in the *Journal of the American Chemical Society* for May, 1949.

This new method of synthesis has several advantages over those previously used. The primary advantage is that 60 to 70 per cent of the amino acids can be converted into the desired peptide, whereas previous methods gave 20 to 50 per cent yield. The steps in the new synthesis are considerably simpler to carry out and, in many cases, much less time-consuming. Furthermore, sulfur-containing compounds present no special problem, although they are difficult to handle by conventional means.

It is anticipated that the new synthesis will contribute to a better understanding of the chemical nature of toxins, allergy-producing agents, hormones, enzymes, and viruses, by facilitating the synthesis and study of peptide models. It is possible that the advantage of the new method will permit synthesis of some simpler, naturally occurring peptides of interest in the medical world.

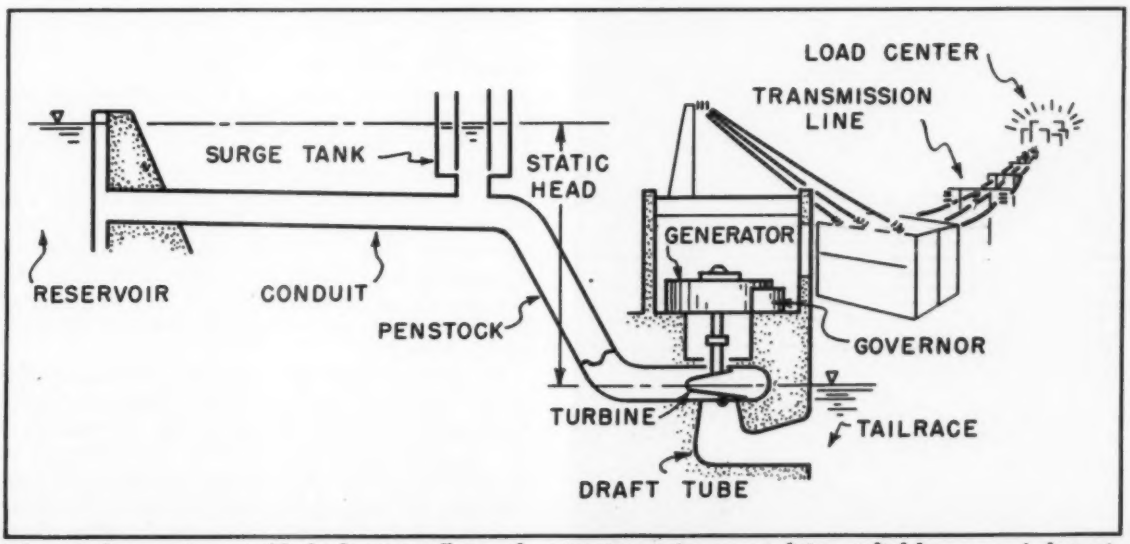
Transients in Hydroelectric Systems

More efficient use of water supplies and water power, coupled with greater precision in the operation of electric clocks, may well be two of the more direct results of studies now going on at the Institute. Under a special grant from the Research Corporation of New York, the hydraulics division of the Department of Civil and Sanitary Engineering is studying the behavior of hydroelectric power systems when subjected to changes in operating conditions.

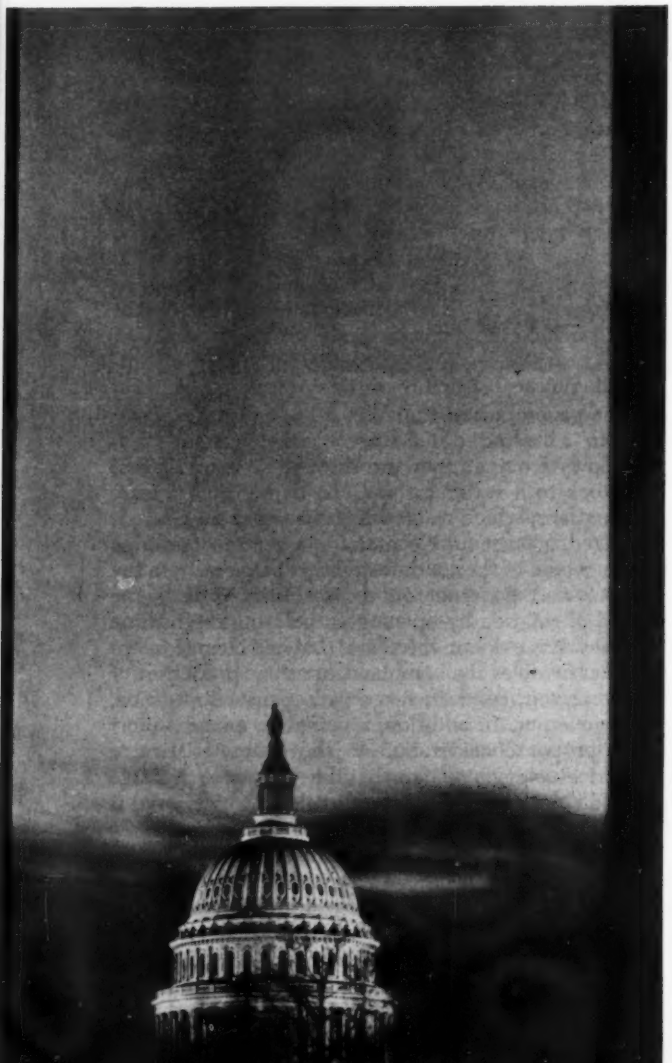
The maintenance of constant voltage and frequency of electric generating systems, although an old problem which has been studied in the past, has again assumed great importance in recent years, both because of the consumer demand for accurate electric timing, and because of the growing practice of interconnecting several power generating systems to provide greater reliability of service. Because of the limitations of methods of analysis before World War II, earlier analyses of the transient behavior of hydroelectric systems were based on oversimplified approximations to true operating conditions. The results thus obtained are no longer good enough for operation of modern generating systems. In the present study, electronic analogue computers are employed, not only to increase the speed of calculation, but also to find solutions to problems so complicated and difficult that machine methods offer the only practical means of solving the nonlinear differential equations representing the physical structure of the system.

The general arrangement of a hydroelectric power system is illustrated in the accompanying figure. Water flows from a reservoir through a conduit and penstock to a water turbine. To damp out pressure fluctuations, which result when the water flow rate is changed, a surge tank containing a central standpipe is connected to the conduit slightly upstream from the penstock. A governor on the turbine regulates the speed of rotation by opening and closing the turbine nozzles. It is evident, therefore, that any change in operation involves the combined transient properties of the reservoir, conduit, surge tank, penstock, turbine, and governor. In addition, a complete analysis must give proper consideration to the characteristics of electrical elements; namely, the generator, voltage regulator, and transmission-distribution network. It must also take account of the load characteristics.

As a start of what is hoped will eventually be a complete analysis of the above system, Henry M. Paynter, Jr., '44, instructor, and co-workers in the Department of Civil Engineering are analyzing a system consisting of a reservoir, conduit, surge tank, and gate. The latter is merely a valve in the line which approximates the adjustable nozzles of the water turbine. The first problem up for detailed study is the behavior of surge tanks – devices incorporated in all hydroelectric systems to



Schematic diagram of a typical hydroelectric installation whose transient performance is being studied by means of electronic analogue computers.



Philip Gendreau

help eliminate changes in water pressure as gates and valves are opened and closed. Mr. Paynter plans to make a thorough analysis of such tanks, and hopes to determine a way to definitely ascertain the sizes and designs most suited to particular needs.

Of the various types of computing machines that might be used for such studies, the most suitable seem to be the electronic analogue type. Analogue computing components may be assembled to solve a part of a large problem, after which more components may be added to include additional parts of the problem until finally a machine is constructed which will solve the entire overall problem. For the hydroelectric problem, computer elements have been combined to indicate the transient conditions caused by the interaction of the reservoir, conduit, surge tank, and gate for comparison with and extension of the calculations that were carried out manually. Results from the machine are indicated by a curve which is traced on an oscilloscope. In typical examples which have been observed the fluctuations of water level in the standpipe are indicated as a function of time when the water flow is started and stopped in a given flow system.

Reliable agreement has been found between the results from the computing machine and those obtained by manual computation. Additional solutions are now being obtained with the computing machine for other types of surge tanks and for other changes in the system. More analogue components are being prepared for the next step in the expansion of the problem, which will take into account the dynamics of the governor in operation of the gate.

Something New, Something Old

GAR WOOD'S *Miss Americas,* the motor boats that for many years made and remade the world's speed records, were a far cry from the ancient double-hulled sailing canoes of the South Seas. His latest venture into naval architecture also has the earmarks of the ultramodern – Diesel engines, variable pitch propellers, plywood hulls, and other features confusing to a simple South Sea native. Yet the kinship of Mr. Wood's vessel with the double-hulled craft made of logs and lashed with coconut fiber is startling.

This vessel, the *Venturi,* is a Diesel-powered catamaran 188 feet long and 40 feet wide. Quite possibly it may be the largest twin-hulled ship ever built. Constructed with considerable attention to weight reduction, the vessel displaces only 128 tons and its 1,200 horsepower engines have already driven it at the most respectable speed of 26 knots. The ship was originally intended to be a remote controlled and armored target, resembling an aircraft carrier, but was built too late to see service in this capacity and was reacquired by Mr. Wood.

The craft exhibits the roll-resistance characteristic of the catamaran, and has been reported as making hard rudder turns at full speed with the remarkably low heel of about two degrees. To observers acquainted only with conventional single-hulled ships, however, the most astonishing aspect of the design is that the hulls are not of symmetrical outline. On the outside, each hull is straight until about a third of the

way from the stern, where it begins to curve in gently. The inside lines of the hulls are curved more or less like the outside of an orthodox boat, but in reverse. Thus the distance between the hulls at the bows is virtually the full breadth of the ship, but the hulls then belly in toward each other so that, well past the center of the ship, there are only about 24 feet between them. The area between the hulls looks like a cross section through a Venturi tube – thus the name *Venturi* originated.

Mr. Wood envisions a much larger ship of this type, weighing in the neighborhood of 16,000 tons. It would have roughly the same outside dimensions as the *Queen Mary* but could carry twice as many passengers and could be driven to perhaps 36 knots with about 120,000 horsepower. The *Queen Mary* uses 200,000 horsepower to reach some 32 knots. Offhand, it would seem that the future of the catamaran as a cargo carrier is less bright. For the same capacity it would inevitably require more hull structure and wetted area. As a passenger ship, its inherent roll stability and greater deck area are definite assets.

More traditionally, the catamaran has been known since the days of Lord Anson who circumnavigated the globe about 1740 (and who during his voyage took a Spanish treasure galleon from Acapulco that was worth 500,000 old-fashioned British pounds). Other sailors, including the New England whalemen, continued to report on the astonishing speed of the asymmetrical hulls, and of their ability to lie much closer to the wind than the European ships of the period. The catamarans and outrigger canoes were built without benefit of metal fastenings or Western methods of construction and were hardly designed to impress American and European eyes with their seaworthiness. Nevertheless, it would seem that the speeds reported for these little boats – up to about 18 knots – would have made more of a stir since the fastest single-hulled ship ever built, the *James Baines*, made its record breaking 21 knots on a displacement of 2,515 tons and a length of 266 feet.

One of the few serious students of the catamaran in this country was the late Nathanael Greene Herreshoff, '70, who built several such craft between 1879 and 1885. At first he did not maintain a rigid connection between the hulls, and in fact patented ball-and-socket designs that allowed the hulls to work independently to some degree. (The tendency today is to tie the hulls together very stiffly, and to claim some aerodynamic lift from this bridge.) Captain Herreshoff used to race the Fall River Line steamers down Narragansett Bay in his catamarans, and with a stiff wind could draw away from these 16-knot ships. As far as photographs show, his hulls were symmetrical, and he either did not know about, or chose to ignore, the slightly bizarre lines that the Polynesians, through centuries of trial and error (and with hydrodynamic justification) had developed for these craft. In 1945 the Herreshoff yards built a 25-foot experimental catamaran called the *Sea Spider* to examine its production possibilities. It was not an unqualified success, although it could be driven to 15 or 16 knots. The type has not caught on as a pleasure or racing craft in this country. Perhaps one reason for antipathy toward it is

A. W. Kruse from Black Star

that it has been barred from competition with single-hulled yachts for the last 70 years. At least one triple-hulled sailing boat has been built in this country.

As presently constructed, the two hulls and connecting structure of a catamaran do not make it an inexpensive craft, and some of its sailing characteristics may come as a surprise to a yachtsman inexperienced with the type. For example, the great righting moment (or torque for a given displacement) which is the factor that permits the catamaran to carry relatively immense amounts of sail in stiff winds, is at a maximum just as the weather hull is lifted clear of the water and when the heel, by conventional standards, is scarcely worth mentioning. As a well-ballasted keelboat heels over, it simultaneously increases its righting moment and spills the wind out of its sails, thus reducing its overturning moment. It is, therefore, inherently stable, and if it is decked over so that it cannot be flooded, it will not capsize. The catamaran, however, has a critical angle of stability and if chance or an unalert helmsman permits that angle to be exceeded, the boat will overturn.

One of the most unusual catamarans now in existence is the *Manu Kai*, built in the Hawaiian Islands along traditional Polynesian lines but with modern aircraft construction. This 40-foot craft, carrying only 370 square feet of sail, is reported to have done more than 22 knots. That it has made long ocean voyages successfully is not surprising considering what similar boats have done over the centuries. This craft can be seen in the photograph on page 584 in the *National Geographic* for November, 1949.

Seeing Molecules

EVER since the 1930's, when the first unit was built, it has been known that the resolution of the electron microscope is sufficient to permit direct observation of the larger molecules. Only recently, however, has it been possible to prove, by the regularities and characteristic forms photographed, that individual molecules can, indeed, be definitely observed.

For the first time, a procedure has been developed in the Department of Biology for resolving the molecules of the protein, edestin, in photographs. The photograph reveals groups of these protein molecules in the crystalline state and gives information concerning their size and weight. The new procedure represents another advance in the rapid development of electron microscopy, which is making possible the direct visualization of colloidal particles, components of cells and tissues, and even the smaller viruses. Since the edestin molecule (whose molecular weight is 290,000) is not very large for proteins, the direct visualization of it represents a significant step in science. The technique, developed by Cecil E. Hall, '48, Associate Professor of Biophysics, is as follows:

Edestin crystals are deposited on a specimen screen with collodion film. Since the crystals themselves are relatively opaque to the electron microscope, a "transfer shadow" is employed to render the surface structure visible. A specimen is placed in an evacuated bell jar and coated with uranium or nickel, evaporated from a hot tungsten filament placed off to one side. The uranium or nickel does not, of course, deposit uniformly over the surface but does so in a manner which reveals the surface irregularities. The surface is then coated with an evaporated film of silicon oxide which forms the next backing. Next, the collodion is washed off with acetone, and the residual protein with dilute hydrochloric acid, leaving a film of silicon oxide with the uranium or nickel deposit representing in relief the edestin crystal.

An attempt is now being made to extend the techniques employed in this study to obtain photographs of even smaller protein molecules.

The Story of Vermiculite

RELIABLE records indicate that the story of vermiculite began in 1824 when one of the early American scientists, Thomas H. Webb, found a sample of this mineral near Worcester, Mass. He took it home with him and tried to investigate its properties. According to the chemical knowledge of that time such an investigation consisted mainly in trying to dissolve it in various liquids and, if that did not yield any results, in calcining it.

It was the result of this calcining which led to the name of the then new mineral. "If subjected to the flame of a blowpipe, or that of a common lamp, it expands and shoots out into a variety of fanciful forms, resembling most generally small *worms* having the *vermicular motion exact*. . . . I term it Vermiculite . . ."* This expansion, or exfoliation, as it is also called, is not only visible, it is also clearly audible, and the sound resembles a crackling brush fire except, of course, that it is much fainter. Webb seems to have been too surprised to measure the expansion exactly. It is now known that the volume of exfoliated vermiculite is about 16 times the volume before expansion takes place.

In the course of the Nineteenth Century it gradually became known that vermiculite is not really rare. Small quantities of it can be found in many places all over our planet, especially in such places as where mica occurs, since the two are somewhat related. In fact, more than one scientist began to suspect that reports of Persian and Indian magicians, who "caused stones to grow" before the eyes of their audiences, actually referred to exfoliation of vermiculite. It is easy to see why the spectacle of a stone expanding with crackling noises and weird motions would be accepted as magic by an untutored audience, especially since the same stone seemed to turn into gold or silver in the process. The material does acquire a golden sheen when exfoliated, and it is sometimes found in this state.

Vermiculite may have fooled prospectors on occasion because of its golden sheen. One can only say that anybody who thought it to be gold must have been quite untutored and inexperienced since real gold is one of the heaviest metals, while exfoliated vermiculite is lighter than cork and cannot get considerably heavier than water even when soaked with moisture. Prior to expansion, it looks black or blackish brown and resembles wood that has rotted in the ground.

(*Continued on page 219*)

* *American Journal of Science*, 1824, VII: 55.

Weapon of the Next War—I

The Probable Nature of Any Future War Provides Cogent Reasons for Rapidly Building Structures for World Security. Some Modern Instruments of Warfare Are Appraised Herewith

BY M. H. WILLIAMS

THE current publicity which is being given to the development of rockets and guided missiles, together with the atomic bomb, has resulted in much serious thought, as well as conjecture, by individuals in the Armed Forces concerning the part to be played by their respective services in any future war. One method of arriving at a logical conclusion would be to trace the development of rockets and guided missiles; but, since this is an era when a new discovery might instigate a complete technical revolution, any examination of the subject must of necessity be considered in very general terms.

Rockets are an old weapon of war. The Chinese first used them in the Thirteenth Century and they were employed by various Western nations for the following 500 years without any spectacular results. However, late in the Eighteenth Century, they were used effectively against the British by Tippoo Sahib and, as a result of this Indian success, an Englishman named William Congreve developed the war rocket to a point where it became a serious rival to the smoothbore guns of the day. In fact, every European army had a corps of rocket artillery as part of its organization during the early Nineteenth Century.

The rocket was then superseded by rifled artillery and for nearly a century it was employed principally for lifesaving, signaling, and other special chores. It was not used in a significant role again until 1940 when its return was made possible by the mastery of new engineering techniques as well as a greater appreciation of its potentialities. Ten years ago, many people, including military leaders and engineering experts, had no faith in rockets; yet today, rockets not only have already played a major part in warfare, but are challenging both artillery and aircraft, and promise to be a decisive weapon in any future conflict.

During World War II only flying-bomb types of pilotless aircraft, culminating in the famous *V-1*, were employed by the Germans, but future possibilities are already assured, not only in the ability of the machines to deliver explosives to a distant location, but also for reconnaissance and the destruction of enemy aircraft by collision with launched short-range projectiles. By the end of the war the Germans had, in advanced development, rockets carrying out all three of these functions, but the future pilotless aircraft will certainly be jet propelled or rocket propelled. In effect, then, the present distinction between pilotless aircraft and rockets will soon disappear.

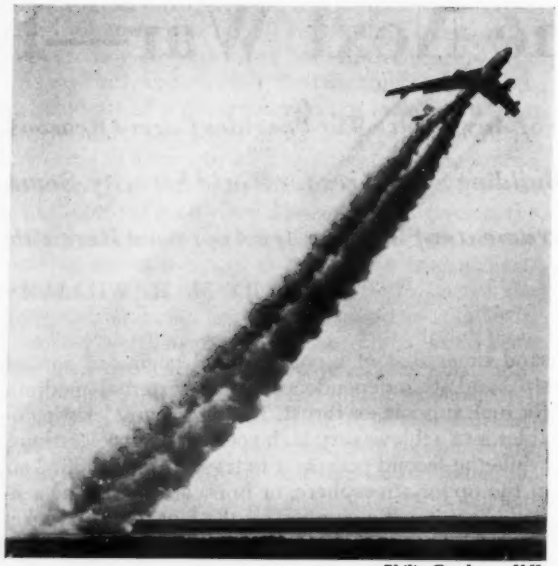
The rocket has two dominant characteristics in its enormous rate of power generation, more than a thousand times that of a conventional engine of similar size, and its independence of any external medium for fuel, support, or thrust. The first characteristic enables it to achieve very high speeds and accelerations, while the second permits it to travel in the rarefied air of the upper atmosphere, or in no air at all. The second characteristic emphasizes the fact that the rocket exerts no recoil, an important, and in some ways, an overwhelming advantage over ordinary artillery.

Some Fundamentals

The performance of a rocket depends upon certain technical considerations. The most important of these is the jet velocity which in turn depends upon the type of fuel used and the efficiency of the motor. Using the most powerful chemical fuels, this velocity has a theoretical maximum of about 12,000 miles an hour. The *V-2* rocket was comparable, according to its designer, with that of the airplane at the close of World War I, as far as development was concerned. Yet the *V-2*, which represents an early stage in rocket development, had a jet velocity of 4,770 miles an hour.

A rocket motor with a certain performance can be used in two ways. First, it may be employed to drive the projectile or aircraft at a certain velocity which is then maintained as long as the fuel supply lasts, usually a matter of seconds or at most a very few minutes. Air resistance prevents the machine from reaching more than a fraction of its theoretical speed, and the flight or trajectory ends soon after the failure of the fuel supply. Consequently, this is a short-range, low-altitude application of the rocket in which the maximum speeds attained are usually less than the velocity of sound.

The second use, exemplified by the long-range rocket, *A-4* (*V-2*), is for those cases in which the motor imparts the greatest possible velocity to a machine which, for most of its flight, travels as a free projectile at such a height that air resistance is almost negligible. It is by this method, and this method alone, that the rocket is used efficiently. The atmospheric applications are all extremely wasteful of fuel and are only justified by high performances which cannot be obtained in any other way. For example, in a vacuum, where its motor could still operate (although its control surfaces would, of course, be useless) the *Me-163B* would attain a speed of 2,700 miles an hour when it had burned up all of its fuel. In practice, however, once it has reached a velocity of about 600 miles per hour, all the remaining fuel is used to overcome drag.



Philip Gendreau, N.Y.

If air resistance is neglected, it is a relatively simple matter to design a rocket which will travel at twice the velocity of its exhaust. As far as present fuels and motors are concerned, this would mean 10,000 miles per hour. Theoretically the speed can be increased by increasing the fuel load, but such an increase in fuel will soon reach the maximum limit due to the size of the rocket, even if the entire pay load is sacrificed. A rocket capable of traveling at three times the velocity of its jet would have to consist of 95 per cent fuel by weight. This obviously would not be a practical weapon.

This is only part of the story, however, for in addition to the loss due to air resistance, a rocket has to expend fuel to support itself against the force of gravity. This fuel could otherwise have been used to increase the final velocity of the rocket; so, when one considers the two losses, plus the actual velocity, the theoretical velocity is as shown below:

	Miles per Hour
Air Resistance Loss	1,000
Gravitational Loss	1,100
Actual Velocity	3,400
Theoretical Velocity	5,500

If launched from the top of a mountain, a very long-range rocket would gain considerably in velocity, for the density of air is cut in half at an altitude of four miles, and the air resistance would be lessened. Then, too, higher accelerations would be possible with a consequent reduction of gravitational loss. Obviously, this point has definite strategic implications.

The range of a rocket depends upon its velocity at the instant that its fuel is burned up, for from that moment on, it takes on the characteristics of a normal projectile. If a rocket attained a speed of five miles a second (18,000 miles per hour), it would have infinite range, inasmuch as it would never return to the earth. Such high speeds are, however, unnecessary, for science has proven that the range of a rocket can be increased greatly by the use of wings which come into play at the end of the free trajectory and enable the rocket to enter a high-speed glide. The German *A-9* was to have an 800-mile trajectory (as an upper step of the *A-10*), after which it entered its glide at 8,000 miles per hour and so achieved a total range of 3,000 miles. Speeds of four miles per second (14,400 miles per hour) would suffice for the greatest possible terrestrial ranges, and such speeds can be obtained by step rockets, launched from high altitudes.

Rockets Applied to Warfare

Rockets of the short-range class have already played an important role in war, particularly when they were used by aircraft for ship and ground attack. They produce no recoil and require only very light launching equipment. Therefore, a large number of projectors may be concentrated in one spot, lay down a short-range barrage of an intensity impossible to secure by other means, and then be quickly moved to a new location. Examples of this employment included the "Katushka" rocket barrages of the Russians at Stalingrad, and later uses by our own forces in attacks or amphibious landings. In this method of employment, the short range and inaccuracy of the weapon are not too important, for area coverage is desirable, and if barrages are ever used in future wars they probably will be provided by rockets rather than by the standard types of artillery.

The lack of recoil has made possible the design of weapons with great fire power which can be operated by a very small crew or even by a single man. The bazooka is an example and it may have marked the beginning of the end for tank warfare. A few infantrymen equipped with the latest improved rocket weapon can now destroy the largest tank, and one must bear in mind that while the bazooka is only in the beginning of its development stages, the amount of armor plate that a tank can carry appears to be approaching its limit.

The rocket mine appears to have great possibilities as a particularly effective antitank weapon with the invention of a short launching platform buried vertically in the ground and, although more difficult to install than a normal antitank mine, would be much more effective against armored vehicles.

Air-borne rockets have already radically affected aircraft fire power and there is no reason to believe that the progress will not continue. For example, the largest gun installed in an airplane so far was the 75 millimeter. It weighed 760 pounds and fired a 15-pound shell containing only 1.5 pounds of high explosive. Suppose that this 760-pound gun was replaced by 12 rockets weighing 60 pounds each. Such a replacement would not only provide for greater destructive power but also would not reduce the airplane's performance by the dead weight of the gun. Authorities have admitted that the fire power of a rocket-carrying fighter equals that of a six-inch gun cruiser, and there is no limit to the size of projectile as long as the airplane can lift it off the ground. Airplanes fitted with such weapons may well have the capability of preventing the movement of armored units unless the latter are protected by air cover.

(*Continued on page 220*)

Living in an Atom-Bomb World

What We Have Most to Fear Is Not Any New Means of Destruction, but Simply Ourselves. The Atom Bomb Is Just Another Instrument of Mass Destruction

BY M. F. ASHLEY MONTAGU

GENERALLY unknown is the fact that when the atom bomb was put together by those scientists who made it, they unanimously agreed to petition the President of the United States not to use it as a destructive weapon. They strongly urged that the Japanese Government should be informed of its existence and that the United States Government would be willing to release it over any uninhabited Japanese territory specified by the Japanese Government. For reasons best known to himself, the President declined to act upon this suggestion, and the world witnessed the spectacle of a civilized nation taking upon itself the moral responsibility of destroying two Japanese cities, and killing and maiming several hundred thousand human beings.

That any other nation would have done the same may, or may not, be true. Certainly no nation that has been Westernized to an appreciable extent would have desisted. Western man has become so calloused to the meaning of life that he has virtually lost respect for it. Some men even talk of wars less intelligently than they do of the common cold. To avoid the latter, they will take some precautions; but to avoid the former, they do nothing. They blandly believe that wars are inevitable, that wars are as natural as fighting between animals, that the impulse to make war is inborn, and that there is nothing to be done about it. Nothing could be further from the truth. Wars are fought for artificial reasons and arise from artificial causes. They are fought with artificial devices, and they are as stupid as they are unnatural.

Man is, by nature, a peace-loving creature. It is through education, by the processes which are borne in upon him in the course of his transformation into a human being, that he becomes aggressive and sympathetic to any and all belligerent invitations which are extended to him. The Eskimos do not understand the meaning of war; neither do the Australian aborigines; nor do the nonliterate peoples of Siberia — the Chuckchi, the Yokut. All of these peoples are characterized by cultures in which the idea of war is nonexistent. War is simply *not* one of the ways in which these people solve problems which Western nations are accustomed to put to the arbitrament of war.

If we do not solve the problem of the atom bomb, these people might well survive us. The atom bomb will not see the end of the human species. We can be quite sure about that. But do we want the atom bomb to be the end of our civilization? Of ourselves? Of our posterity? It is not sensible to answer, "We do not," for what we wish, and hope, and believe is not what we say, but what we do. If we are to evaluate the answer in terms of what we do, rather than what we say, the logical conclusion is that we do wish to see the end of ourselves, and of our children and their children.

Most people have been frightened by the atom bomb; it might be dropped on them. They are not, however, averse to dropping it on others. As long as people continue to think and act in that way, there can be no hope whatever that we shall be spared the treatment we accord to others.

What we have most to fear is not any new means of destruction, but simply ourselves. The atom bomb is just another instrument of mass destruction. We, who created it, can outlaw it, or at least we could so long as we were the sole possessor. But that will do us little good until it is possible to outlaw that thinking which makes it possible to use such destructive instruments against our fellow men. So long as anyone maintains overt or covert hostility toward human beings because they are in some way different, war and destructive weapons will be employed.

So long as we continue to think that we are in competition with other human beings, we shall continue to compete with them. Friendly competition may act as a spur or stimulant, but hostile competition too often leads to the use of force. So believing in the use of force, we shall segregate potential competitors whenever we can, so that they may be handicapped in the race with us.

A Living Brotherhood

Mouthing beautiful Christian sentiments about loving others as ourselves and of brotherly love, we shall discriminate against others because they are of another skin color, or religion, or culture, or nation. We shall oppress, coerce and exploit, fear and hate, and these things shall become so habitual to us that we shall scarcely, if ever, be aware of our crimes against our fellows. To prevent the danger of becoming conscious of such things, we shall build up a system of rationalization about the inferiorities of other peoples and convert our prejudices into laws of nature, which have but to be taken for granted to be lived with a more or less easy conscience. So to live is to live ever nearer the brink of inevitable disaster. There is only one thing that can save us, and that is to stop talking about brotherhood and to live it.

"No man is an *Iland,* intire of it selfe; every man is a peece of the *Continent,* a part of the *maine;* if a *Clod*

bee washed away by the *Sea, Europe* is the lesse, as well as if a *Promontorie* were, as well as if a *Mannor* of thy *friends* or of *thine owne* were; any mans *death* diminishes *me,* because I am involved in *Mankinde;* And therefore never send to know for whom the *bell* tolls; It tolls for *thee.*"

Written in 1624, John Donne's beautiful words express the eternal truth by which men must live if they are ever to live happily together. Whether anyone likes it or not, one world is today already a functional reality. The voice of man can travel to any part of the earth within a fraction of a second. Communication on the physical plane is now possible between all the peoples of the earth, and most human beings want to communicate with us, not only physically, but socially. They want us to be as actively interested in them as human beings as they are interested in us. They want to learn from us, and they want us to help them, as many of them have taught and helped us.

To us, who are so sophisticated, the nonliterate peoples appear as humble and rather undeveloped members of the human family. Yet, humble and technologically undeveloped as they may be, they are often the bearers of spiritual riches and ways of life from which we could both learn and gain much.

We of the Western world have been too vain and egotistical, too prideful and patronizing to notice the riches which those, whom we had condemned to an inferior status, had to offer. We have already brought the atom bomb to the peace-loving people of the Bikini atoll. We have made their immemorial home uninhabitable, and not one of us protested against this outrage. We believed that the atom bomb had to be tested, and we blandly consented. The people of Bikini had solved the problem of living together. We haven't. The problem of living in the modern world will have to be solved by the peoples of the Western world – the peoples, in effect, who created the atom bomb.

As James F. Byrnes, former Secretary of State, has put it: "We live in one world, and in this atomic age regional isolationism is even more dangerous than is national isolationism. . . . Today the world must take its choice. There must be one world for all of us or there will be no world for any of us."

Indeed, as the Federation of American Scientists has declared, no nation can, in this new age, feel secure until the problem of the control of atomic power is solved on a world level. That solution can only be a moral and political one. It is a solution which cannot come from one people, one nation, but must come from all peoples, all nations; and, the solution can and must come in the same manner as the bomb was created, that is, by co-operation between nations. It was the work of Mendelyeev, a Russian; of Thompson, Rutherford, and Chadwick, Englishmen; Einstein and Hahn, Germans; Bohr, Norwegian; Meitner, Austrian; the Curies and Joliot-Curies, Poles and Frenchmen and women; Fermi, Italian; Anderson, American; and Yukawa, Japanese, which made the atom bomb possible.

By putting together the ideas developed, and the discoveries made, by all these scientists, the atom bomb was produced. Why can't we put the ideas and discoveries for the maintenance of man's life in peace and universal amity to work in the same way? The answer is that we can and must. Another war will mean the suicide of Western man. The destiny of Western man is being decided now, at this moment, by each and every one of us. Each of us, as a citizen, is a possessor of great potential power. Each of us can play a most important part in seeing to it that the the right decision is made about the atom bomb.

It should have been obvious all along that atomic "secrets" could not be kept for more than a few years by any nation or small group of nations, and that there can be no assurance that peace will be maintained as long as any nation has the sovereign right to decide questions of war and peace for itself. Peace is not merely the absence of war but the presence of justice, law, order – in short, of government.

A World Law

World peace can be created and maintained only under world law, universal and strong enough to establish justice and prevent armed conflict between nations. The only way by which a people can assure its survival and preserve its liberties is to unite with other peoples for the creation of a world government to which shall be delegated the powers necessary to maintain the general peace of the world based on law and justice.

As now constituted, the United Nations is a league of sovereign states bound together by treaty, not by world law. As such, it is not a world government and, therefore, cannot by law prevent armed conflict between nations and establish justice and security. Nevertheless, it is the greatest step yet taken by mankind toward world peace. Since the charter provides for amendments, every effort should be made to transform the United Nations into a world government.

Such objectives cannot be reached overnight; but, despite all difficulties, these objectives can, nay must, be accomplished. We must help build support for world government, and we must start now. The time is short. We must convince our friends, and get them to convince theirs, of the urgency and manner in which they may work to make world government a reality. In the first place, we must become clearly aware of the issues involved, and these may be summarized as follows:

(a) There is absolutely no defense against the atom bomb.
(b) No system of inspection could prevent its secret manufacture.
(c) No law-enforcing authority could prevent its secret manufacture.

It is only by the creation of a concert of nations, all of whom will work in harmony with one another in a common world government, that any nation can be assured against the use of the atom bomb. To this end, therefore, it should be sought to introduce the following proposals to the United Nations:

1. That the United Nations be transformed from a league of sovereign states into a government deriving its specific powers from the peoples of the world;

(*Continued on page 228*)

The Delayed Invention

An Idea Endorsed by Hundreds of Engineers Has Never Been — and Possibly Never May Be — Built. So Arises the Question, "Why Not?"

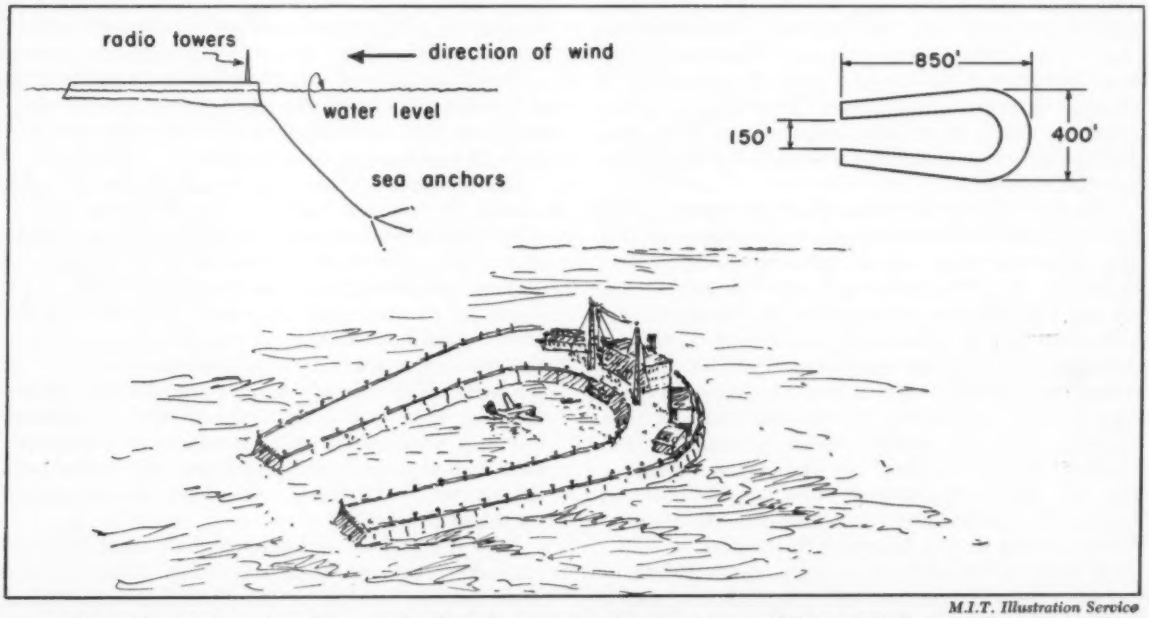
BY WILLY LEY

HISTORICALLY the next 10 years may still prove me wrong about the theme of this article. If so, I'll be delighted. But if history doesn't prove me wrong, chroniclers of 2050 A.D. will write that there was a marvelous invention around during the first half of the Twentieth Century, but that this invention was not realized because there was no need for it. Or rather, yes, there was a need for it but it was not built because it wasn't quite practical. No, to be precise, it *was* practical and there *was* need for it, but the necessary capital was lacking. Even that isn't quite correct. Capital was available and would have been – oh, well, the invention just didn't happen to come off. I am speaking about the idea of the floating airport or seadrome, an artificial landing place for aircraft, discussed in numberless articles and made into a movie called *FP–1 Doesn't Answer.*

The idea originated very soon after World War I. The war had ended and international commerce could start over again. The most important single international traffic and tourist lane was the London-New York run. The existing large ocean liners which had survived the war were more or less obsolescent. Airplanes, on the other hand, had ceased to be merely experimental. It would be nice to open a transatlantic air line, but the drawback was that airplanes could not yet fly the Atlantic. If only there were a few islands in the proper places, and at the proper distances from each other.

At that point somebody thought of a solution: why not build such islands? No real islands, of course; that would be impossible in a depth of water of never less than a mile and usually around two miles. But floating islands, places where an airplane could land and re-fuel, or wait out a period of bad weather, were possible. Partly because the Swiss-German firm of Dornier had just started building a successful line of flying boats at that time, and partly because ocean flying loomed important at the time, the first design for such a floating seadrome was tailored to fit the needs of flying boats.

It was to be a horseshoe-shaped steel structure, clad with thin armor plate, about 850 feet long and 400 feet across at the widest part. Such a structure, secured in position by sea anchors reaching down into layers of the ocean where there are neither waves nor currents, would always head into the wind and would create a large and quiet lagoon for flying boats and pontoon airplanes. The two "legs" of the horseshoe could also serve as runways for smaller



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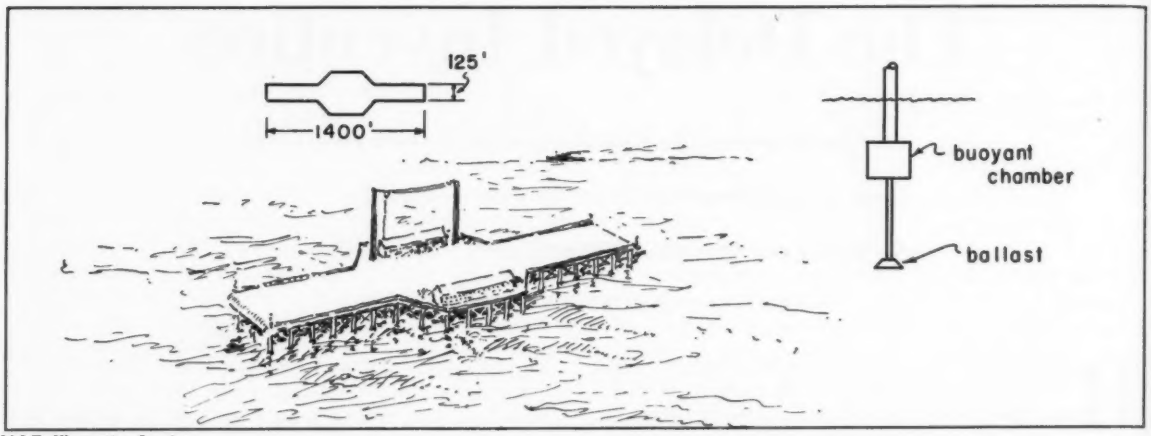
Among the earliest designs of seadromes to facilitate transoceanic flying was the type of floating island pictured above, providing a lagoon for flying boats and pontoon airplanes, and runways for smaller craft.



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airplanes. There were to be a repair shop, a few hangars, a radio station, a hotel, and even two ocean-going tugs to tow in flying boats which might have made emergency landings. It made exciting and impressive pictures and while there was no doubt about the usefulness of such structures, naval engineers began to wonder about the problem of building one.

A more or less solid horseshoe of such size would be endangered by wave action. It would have to be both rigid and flexible at the same time. There was virtually no experience with such a design. And it would cost a lot of cash, especially since one such seadrome would be of little use; about half a dozen were needed for the aircraft of that time.

After some discussion the design was quietly filed away, pending improved aircraft on the one hand, and a better seadrome design on the other. Nor did an attempt at saving the idea do much good. That attempt consisted in preserving the feature of the quiet lagoon without subjecting the seadrome itself to wave-action stresses. It was "an arrow in a circle." The arrow was just a long and fairly narrow platform, held in position by a sea anchor and turning always, it was hoped, into the wind. The circle, more than 2,000 feet in diameter, was to consist of a number of concrete pontoons. That ring of heavy pontoons would stop the waves and create the lagoon; the center arrow was to be a runway for land-based aircraft.

There followed about five years of silence, as far as the problem of the seadrome was concerned. During those five years aircraft grew better and better. And then, in 1928–1929, came the "Armstrong Seadrome," named after its designer, the American engineer, Edward R. Armstrong. It aroused a storm of interest and found widespread approval. The Frenchman, Louis Blériot, one of the pioneers of aviation and the first man to fly the English Channel in an airplane of his own design, expressed himself as being enthusiastically in favor of floating seadromes in general and of Armstrong's type in particular. The late President Roosevelt, too, said on more than one occasion that he was intrigued by the idea.

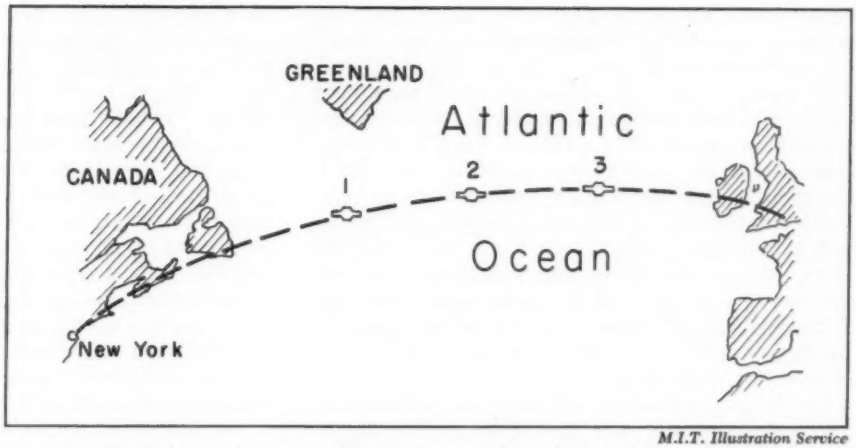
Edward R. Armstrong carefully avoided the flaws of the earlier suggestions. His proposal is so impressive because it is truly a "design" – a plan that has been worked over, and through, from top to bottom by a number of engineers. In fact, other engineering firms were called in for detail, such as the design and construction of the anchor for the whole structure. Reflecting advances made in aviation in the meantime, the Armstrong seadrome was designed for land-based aircraft. It was essentially a gigantic platform, 1,400 feet long and over 350 feet wide, raised 100 feet above the surface of the ocean – 30 feet higher than the highest wave ever recorded. The platform, of course, corresponded to a whole floor, and underneath the flight deck there would be hangars, repair shops, kitchens, laundries, dining and recreation rooms, crew quarters, and hotel rooms; in short, a complete airport and a hotel were to be included in the structure.

The platform was to stand on a large number of hollow "legs," reaching down into the water and then widening out into buoyant chambers below the level of wave activity. Naturally the buoyant chambers were to be accessible through the legs themselves and some of them could be used as storage space. Because the waves could pass in between, and around, those legs, the seadrome as a whole would not be influenced by the waves. Unlike an aircraft carrier, the seadrome would be perfectly stable even in high seas. And while the flight deck might be windswept in bad weather, it would not even get wet unless it happened to be raining.

The whole seadrome was to be anchored to the bottom of the sea, but not directly. The anchor which had been designed was to be a gigantic mushroom anchor, buoyant enough to float at first (for towing into place) and containing the wire rope. When in position the buoyancy chambers of the anchor would be flooded, one by one, in succession; the wire rope would pay out simultaneously from the anchor. But when the anchor rested on the ground the wire rope would not lead up to the seadrome, but to a smaller triangular structure of similar design. This rope buoy, floating almost vertically above the anchor, was then to serve as a surface anchor for the seadrome.

Now it has been said that engineers and businessmen don't ask the same questions: The engineers want to know whether it will work; the businessmen, whether it will pay. The engineers needed little convincing as far as the Armstrong seadrome was con-

Almost a quarter century ago, Edward R. Armstrong proposed the type of seadrome shown on the opposite page. To make transatlantic flying safe, three such seadromes were to be anchored along a great circle route from New York to London, as shown in the map at the right. The Armstrong seadrome was designed to have its landing platform well protected against even the largest waves.



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cerned. One could ask for more specific information on specific points, but it was clear from the outset that the seadrome would be able to do what it was supposed to do. The waves would hardly influence it, the anchor had only to hold it against wind and current, and Armstrong had all the figures ready. The businessmen were somewhat harder to convince. It was possible to figure the probable construction costs for three such seadromes. (It has to be mentioned here that maximum economy was likely to result from three such stopover points: Less than three would not increase the pay load enough; more than three would cost too much.) But when it came to figuring airplane pay loads and so on, a specific type of airplane had to be assumed. Among my papers of several years ago there are cost calculations based on the then new *DC–3*, and one cannot help but smile at these figures now. Who would have the courage to cross the Atlantic in a *DC–3* of that vintage?

Still, the project made fast progress for a while. A scale model (one 32d of an inch to the inch) was built and much photographed. A few sections were built on a larger scale and tested. But then the idea seems to have just petered out. Maybe the slow but sure approach of World War II had something to do with it. But a few such seadromes would have been useful when the war actually came. They would have been fairly invulnerable strong points in the ocean, as they would have been able to defend themselves against air attack by means of their own airplanes, and been able to fight off smaller surface craft by means of guns which could have been mounted there (a steady firing platform at sea!). Also, they could not have been damaged by submarine attack. The seadrome could have been sunk by a submarine only by torpedoing most of the legs on one side separately. In short, nothing could have touched it, except possibly a full-fledged battleship like the *Bismarck*, mounted with heavy naval rifles.

When the war really came the absence of seadromes was generally regretted, and a number of naval engineers began to wonder whether it might be possible to create one in a hurry. One of these suggestions was simple, but it may be significant that Navy authorities permitted it to be published while the war was going on. On the other hand, it would not have helped the Germans much to know about it, because except for sabotage in the dockyard there would have been little they could have done about it. It was simply a very large compartmented concrete "brick" (with 10-foot thick outer walls) which measured 1,500 feet long, 500 feet wide, and 120 feet thick. Inside, it was to be compartmented into 750 watertight cubbyholes (each considerably bigger than a large living room) by means of re-enforced concrete walls a foot thick. Considering that the average waves of an Atlantic storm are almost never higher than 10 feet, it was planned that this brick would float with its topside 40 feet above sea level.

In spite of the enormous size of this brick, it could have been towed into place without too much trouble. Even a very large mass can be moved by comparatively small tugboats provided that fast movement is not a prerequisite. Since this is an important point with regard to any kind of seadrome, let us consider a few figures.

In the 1930's, large log rafts were towed along the Pacific Coast from Seattle to San Diego. These rafts, held together in a primitive manner by chains, weighed more than 15,000 tons, were over 1,000 feet long, some 60 feet wide, and drew 26 feet of water. The power required for moving in any weather was one tug with a 1,000-horsepower engine! This towing job was not done once, but 118 times. Of the 118 rafts which left Seattle, 115 reached San Diego. Two broke up en route, and the third, unbelievable as it may seem, caught fire. The reason why this could be done with only 1,000 horsepower was that everybody was satisfied with an approximate five miles per hour. Marine experts can explain with a few simple figures what happens (they do have the complete formulas, too, of course) and these figures say that between one mile per hour and about nine miles per hour approximately 90 per cent of the resistance is just skin friction which increases with the square of the speed. If 1,000 horsepower will tow something at three miles per hour, 4,000 horsepower would be needed if you want six miles per hour. But above nine miles per hour the wave action enters into the equation, and the power required becomes as the cube of the speed up to about 14 miles per hour. And above 14 miles per hour the power required is as the fourth power of the speed. This explains why the *Queen Elizabeth* needs 80,000 horsepower for 24

knots, while the *Lexington,* for a record-breaking one-hour run which produced 34.5 knots, had to develop 210,000 horsepower.

In short, if you are willing to move something slowly in water, you can move almost anything with a ferryboat engine. This means, in turn, that a seadrome could do without any anchor at all. After it has been towed into place, it can maintain its position against wind and currents by its inherent power —of which there doesn't need to be much. On the route advocated by Armstrong, the fastest ocean current amounts to one and five-tenths miles per hour; if the wind should blow in the same direction, the seadrome would have to develop some five miles per hour to stay in one place.

But I am not finished with wartime projects yet. The large concrete brick was released for publication, but another one was acted upon, and kept so secret that it created a big surprise to everyone when it was published after World War II. At least 8,000 Navy officers of assorted ranks swore that this was a hoax, because, if it were true, "I would have known about it." But "Project Habakkuk," as it was known at the time, wasn't a hoax.

Habakkuk was, or would have been if built, an artificial iceberg, some 2,000 feet long, 300 feet wide, and 200 feet deep. It would have been a tenuous structure if lifted out of the water, consisting of bigger girders holding smaller girders and the smaller girders, in turn, holding piping and refrigeration elements. If dipped into cold Canadian water with the power on, all the empty spaces would have filled up with nice solid ice. Once frozen, it would have been very resistant against melting even in warmer waters; the refrigeration elements could have kept it solid without much fuel expenditure.

Built in the general shape of a ship, Habakkuk was to have a large, flat flight deck for airplanes and lots of antiaircraft batteries scattered over its front section. (I feel hesitant to use nautical terms when it comes to an iceberg.) Six engine nacelles were to stick out from its sides, providing power of movement on the order of five to six miles per hour. The airplanes on the flight deck were to be submarine-hunting attack bombers; they were not meant to defend Habakkuk. The defense was up to the antiaircraft batteries which would fight off any attempt of landing on it. Physical seizure would have been the only way in which the Germans could have neutralized Habakkuk. Shelling or bombing an iceberg doesn't do much good; I spoke to a Navy commander who had been in antarctic waters where they had used a natural iceberg for target practice with six-inch guns. He asserted that every six incher knocked off about enough ice for a round of drinks, provided that the drinking party was small. The studies made about Habakkuk must have progressed to about the point where construction could have been started because there exists a cost estimate saying that $70,000,000 would do it. But by then other methods of submarine hunting had proved successful enough so that there was no need for Habakkuk to materialize.

The facts of life are, as of 1950, that no seadrome of any description exists. At the same time several transatlantic air lines are going full blast, refuting Blériot's statement that the purpose of a seadrome is not to make transatlantic flying possible, but to make it profitable. The transatlantic lines, in fact, seem to operate with less red ink than the others. Just to get an idea about pay loads, fuel reserves, and so on, I queried an air line which operated the same type of airplane (*DC–4* at that time) on the New York–London run (with two stops at Newfoundland and Ireland) and on the New York–Los Angeles run. The latter makes more stops (Washington, D.C.; Nashville, Tenn.; Little Rock, Ark.; Fort Worth, Texas; and El Paso, Texas) but the figures for fuel and pay load read almost the same in both cases.

All of which means that the air lines don't need seadromes. Whether a seadrome would pay, if operated essentially as a novel kind of resort hotel with some incidental air-line patronage, is a different question. Military considerations are another and very different question. Recently the Coast Guard brought up still another point of view. The Coast Guard operates units similar to meteorological stations at sea and uses its ships for the purpose. To maintain one such "station" the Coast Guard needs three vessels with a crew of 120 officers and men each. A small seadrome, estimated to cost $6,000,000, could operate with a crew of 80 officers and men and

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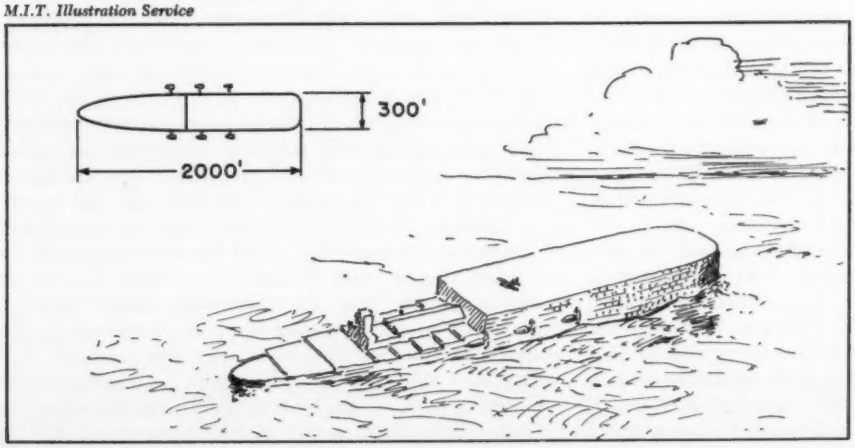


During World War II, a floating "brick" of re-enforced concrete was proposed as a means of quickly establishing transatlantic seadromes.

The most startling of all seadrome projects was the artificial iceberg shown here for use in Arctic regions. It was 200 feet high overall, and consisted of pipes and refrigerating elements in a structure generally resembling a ship. It might have been built at a cost of $70,000,000.

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

On the Lot

Among recent changes in Faculty personnel announced by James R. Killian, Jr., '26, President of the Institute, are the appointments of an assistant professor and an assistant on student placement. In addition, Dard Hunter has been reappointed as head of the Dard Hunter Paper Museum. The present assistant crew coach, Charles O. Jackson, has been named assistant on Student Placement.

Thomas H. Pigford, '48, has been appointed assistant professor of chemical engineering and director of the Oak Ridge Engineering Practice School, effective on February 1. Following his graduation from the Georgia School of Technology in 1943, Professor Pigford served in the United States Navy as technical electronics officer. He became an assistant in the Department of Chemical Engineering at M.I.T. in 1943, an instructor in 1947, and in the same year became assistant director of the Parlin Station. He held the Humble Oil and Refining Company fellowship in chemistry during 1948.

Dard Hunter, whose retirement as curator of the Dard Hunter Paper Museum took effect last June, has been reappointed as honorary curator. As soon as the necessary construction work can be completed, the Dard Hunter Paper Museum will be moved from its present location in the Rogers Building to new quarters in the Charles Hayden Memorial Library. The new location, in close proximity to other facilities for study in the graphic arts, music, and other phases of the humanities, will enable Dr. Hunter, outstanding authority on hand papermaking processes, to extend the services and facilities of one of the most instructive and interesting of the several museums maintained at the Institute.

Also announced were the supplementary appointments of Professor John R. Markham, '18, of the Department of Aeronautical Engineering, to be director of the Naval Supersonic Laboratory at M.I.T.; and George B. Thomas, Jr., Assistant Professor of Mathematics, to be executive officer in the Department of Mathematics, effective on February 1.

Dean of Architecture Resigns

The resignation of William W. Wurster as Dean of Architecture and Planning in the School of Architecture, effective early in 1950, has been announced by President Killian.

Dean Wurster, who has been at M.I.T. since 1944, will return to California to continue active practice with the architectural firm of Wurster, Bernardi and Emmons in San Francisco. He will also serve as dean of the School of Architecture and professor of architecture on the Berkeley campus of the University of California.

Among some of his outstanding works have been the Valencia Gardens Housing Project in San Francisco for the United States Housing Authority, in association with Harry A. Thomsen, Jr.; the Yerba Buena Club on Treasure Island during the 1939 San Francisco Exposition; and Stern Hall, a women's residence hall on the University of California campus in association with Corbett and MacMurray of New York. In addition, Dean Wurster has designed several hundred homes in the San Francisco Bay region.

For Industrial Research

Industrial grants-in-aid totaling $1,150,000 have been made to the Institute in recent months. In making this announcement, President Killian stated that the grants included $250,000 each from the United Fruit Company of Boston, the Cities Service Research and Development Company of New York, the Standard Oil Company of California, and Socony-Vacuum Laboratories, a division of Socony-Vacuum Oil Company, Inc. of New York; and $50,000 each from the A. O. Smith Corporation of Milwaukee, the Phelps Dodge Corporation of New York, and from an unnamed Massachusetts corporatian. All of these grants assist M.I.T.'s current $20,000,000 Development Program of education.

The United Fruit Company's grant is earmarked for investment with endowment and other funds. Income from this grant is to be allocated each year to fields jointly selected by the United Fruit Company and by the Institute.

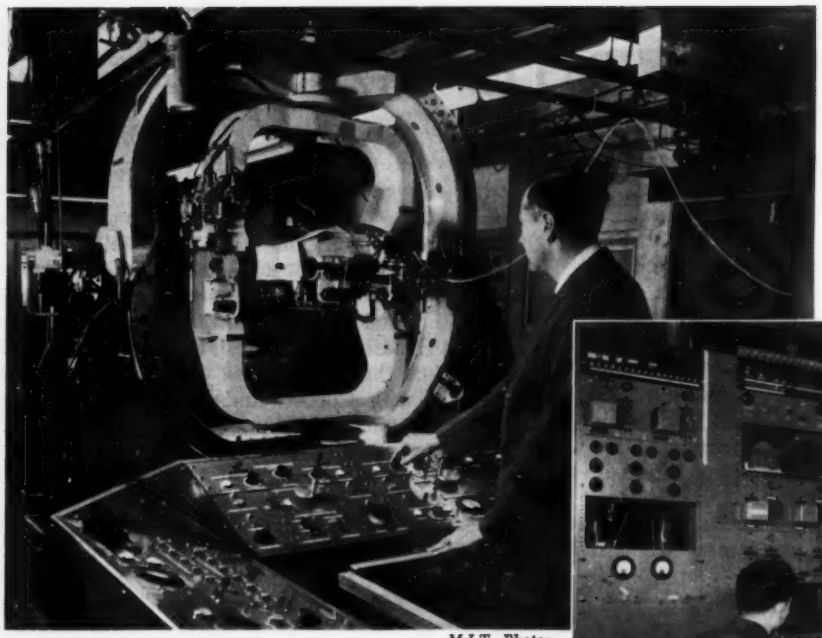
The grant of the Cities Service Research and Development Company is to be applied to research and development work in the fields of nuclear physics and chemistry, mechanical engineering, and chemistry and chemical engineering.

A substantial part of the grant from the Standard Oil Company of California is to be applied to chemical engineering and chemistry, nuclear science and engineering, and research projects in lubrication, friction, and wear and corrosion.

The Socony-Vacuum grant is to be used for both education and research in such fields as nuclear power, combustion, heat transfer, spectrochemical analysis, lubrication, corrosion, and friction and wear. The grant is payable annually in the sum of $50,000 over a period of five years.

The grant from the A. O. Smith Corporation is to be applied to fundamental research in the Institute's extensive metals-processing program. The total grant is payable at the rate of $10,000 per year for the next five years.

The Phelps Dodge Corporation grant-in-aid was made to help fulfill the M.I.T. program of preparing men equipped with a sound knowledge of recent developments in metallurgy and metal fabrication.



M.I.T. Photos

Left: *The flight simulator at the Institute is operated from the control panel at which Albert C. Hall, '37, Associate Professor of Electrical Engineering and Director of the Dynamic Analysis and Control Laboratory, stands. The gimbal frame responds to the various commands given from this board to the theoretical aircraft whose characteristics have been given to the machine.* Below: *Engineers set up certain characteristics of an aircraft for a flight performance check.*

Predicting Flight Performance

OPERATING at the Institute is a new machine designed to check flight characteristics and control equipment of an aircraft prior to construction of the craft. On this elaborate and sensitive calculator, known as the flight simulator, engineers will be able to set up an electrical model of any aircraft which is in an advanced stage of design, and then apply an actual autopilot to fly this nonexistent, theoretical craft.

The autopilot, which may be the "muscle" of either a guiding mechanism for a guided missile, or an automatic pilot for a more conventional airplane, then has exactly the same problem that it would have in the actual flight of the missile or airplane were the prototype built. Thus, the simulator is able to conduct a test flight of an aircraft in the design stage; it is designed to simulate those conditions under which an aircraft can operate.

A combination of intricate electronic and mechanical equipment, the flight simulator represents the results of a co-operative project involving more than 50 engineers and nearly three years' work. It was built under the auspices of the United States Navy Bureau of Ordnance in the M.I.T. Dynamic Analysis and Control Laboratory, of which Albert C. Hall, '37, Associate Professor of Electrical Engineering, is director.

Because it enables engineers to study some of the flight characteristics of any given design before construction is begun, the simulator can save much of the cost and time of flight testing and should help in improving aircraft design. It requires only flight characteristics obtained from working plans and carefully measured data from wind-tunnel tests of a model of the proposed craft. If, for instance, aircraft performance on the flight simulator is not satisfactory, the wing and tail designs of the electrical model may be changed by simple adjustments of the simulator controls until the desired behavior is obtained. Suitable changes can then be incorporated in the plans before the actual airplane is built.

Thus, in an age when airplanes are called upon to fly faster and farther, this machine is expected to save valuable development time by making available, prior to construction, much information hitherto obtained through experimental flights.

"The fundamental purpose of this machine," Dr. Hall explained, "is to permit the development of high-speed aircraft with a reduction in the time, expense, and number of conventional flight tests."

The flight simulator involves the use of intricate computing machines and a flight table on which actual problems relating to flight stability are worked out. The table is an arrangement of gimbals, delicately suspended so that they can incline freely in any direction and supported on an independent foundation so that there will be no vibration.

The gimbal frame, which is operated by very high-speed hydraulic servomechanisms (automatic controlling instruments which carry out motions in accordance with electrically transmitted commands) is used to orient the automatic control system of an airplane or missile just as it would be tested in actual flight. The gimbal frame table rolls, pitches, and goes through all the motions the airplane would make in the air under stated conditions. Although the motions of the gimbal frame table, and thus the actions of the hypothetical airplane or rocket in flight, are recorded on charts, the visual study of the gyrations is of high-

est consequence, too. This is an important way of gaining information, and these visual findings of the engineer can later be checked with the mathematical record.

A problem is worked out on the apparatus by setting electronic computor dials that represent the various important characteristics of the aircraft to be studied – weight, velocity, altitude, wing span, and many others. Before the simulator can be used, many of these characteristics must be obtained from wind-tunnel tests of small models of the proposed aircraft. Then the question is fed into the simulator by applying appropriate electrical signals through a control board. The answer is returned on a chart on a recording apparatus in a matter of seconds.

This computer, one of several types of such high-speed mathematical machines at M.I.T., adds, multiplies, integrates, and subtracts at almost unbelievable speed. For example, a computation which would take an able operator 100 hours to carry out by hand is handled by the computer in 10 seconds, and much more elaborate problems can also be handled in a matter of only minutes.

Among the M.I.T. scientists contributing to the result, John F. Blackburn, of the Division of Industrial Coöperation, developed the automatic controls and supervised the mechanical design of the gimbal frame; Emery St. George, Jr., '43, of the Division of Industrial Coöperation, developed instruments and electronic components; Charles M. Edwards, '40, also of the Division of Industrial Coöperation, designed and developed the electrical computer; and Thomas F. Jones, Jr., '40, Assistant Professor of Electrical Engineering, was in charge of simulator operation.

Frank B. Jewett: 1879–1949

FRANK B. JEWETT, '03, life member of the M.I.T. Corporation, died in Summit, N.J., on November 18, 1949, after a brief illness. He was a former president of the National Academy of Sciences, and a fellow and past president of the American Institute of Electrical Engineers.

Born in Pasadena, Calif., on September 5, 1879, Dr. Jewett received his A.B. degree from Throop Polytechnic Institute (now California Institute of Technology) in 1898 and four years later received a Ph.D. degree from the University of Chicago. He was an instructor in physics in 1903–1904, and a lecturer in 1905–1907 at M.I.T., during which time he took graduate studies at the Institute. In 1904, Dr. Jewett joined the American Telephone and Telegraph Company and throughout the rest of his life was identified with the Bell System. He became the first president of the Bell Telephone Laboratories when it was organized in 1925, and held that position until 1940 when he became chairman of the Board. He retired from active service in 1944.

Dr. Jewett was a term member of the M.I.T. Corporation from 1928–1933, and since 1933 has been a life member. He was president of the Alumni Association during 1939–1940, and from 1925 until a short time before his death served on various Visiting Committees of the Institute.

Altman-Pach

Frank B. Jewett, '03

Life Member of the Corporation, 1933–1949

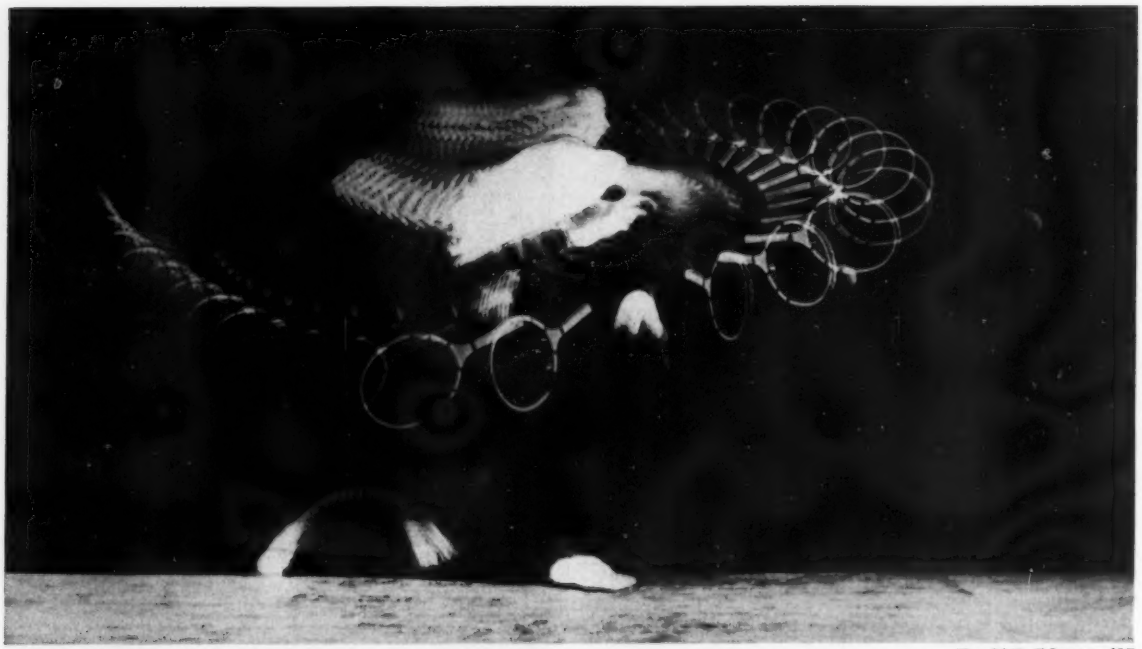
For his work on the vapor density of sodium vapor, magnetic change of resistance in bismuth, effect of pressure on insulation resistance, and particularly in electrical communication, Dr. Jewett has a distinct claim as American scientist.

Dr. Jewett was a member of many scientific and engineering societies and the recipient of many honorary degrees. In recognition of his work for the Office of Scientific Research and Development he was awarded the Medal for Merit in 1946. Other honors he received include the Edison Medal, the Faraday Medal, the John Fritz Medal, the Franklin Medal, and the Washington Award. He was president and trustee of the New York Museum of Science and Industry, and trustee of the Carnegie Institution of Washington, Woods Hole Oceanographic Institute, and Tabor Academy.

Corporation News

APPOINTMENT of Henry Loomis as Assistant Secretary of the M.I.T. Corporation has been announced by President Killian. Mr. Loomis, a resident of Manchester, Mass., has been administrative assistant to the president of M.I.T. since October, 1947. He came to M.I.T. from the University of California, where he was associated with the work of the United States Atomic Energy Commission.

A member of the Class of 1941 at Harvard University, Mr. Loomis held a Navy commission during World War II, reaching the rank of lieutenant commander. On duty with the staff of the Commander-in-Chief Pacific, he served for several years in the Pacific Theater and later briefly in Washington.



Harold E. Edgerton, '27

Shown in the lobby of the Rogers Building at M.I.T. during January was the first comprehensive exhibition of photographs made with stroboscopic light since the development of this photographic technique by Professor Harold E. Edgerton, '27, of the Department of Electrical Engineering. Typical of almost 100 color and black-and-white photographs displayed, is this example of a forehand drive made at the rate of 60 exposures per second, having a duration of 1/50,000 second.

Art in Contemporary Life

HISTORIAN of note and one of the leading figures in the promotion of modern architecture and art, Sigfried Giedion has been appointed visiting professor in the Department of English and History at the Institute for the term starting in February. In announcing the appointment, Professor Howard R. Bartlett, Head of the Department, said that while at M.I.T. Dr. Giedion will conduct a seminar, "Civic Centers and Social Life," and give a series of five public lectures on "The Role of Art in Contemporary Life."

Born in Switzerland in 1894, he was educated there and in Germany and Italy. Trained first as an engineer, he later began the study of art history. As a student of Heinrich Wölfflin at Munich, he became one of the younger exponents of the Swiss historical tradition which began with Jacob Burckhardt. Dr. Giedion's interest in contemporary art and architecture, and his personal contact with the leading artists, shaped his historical methods. His fundamental principle in treating historical phenomena is: "History is never stilled. It is ever in movement like the generation observing it. There are no banal things in History. Relationship and contact with other disciplines form the backbone of History Writing."

When in 1928 the International Congress of Modern Architecture was founded, Dr. Giedion was appointed its general secretary. Such publications of the C.I.A.M. as *Dwellings for the Lower Income Classes* (1930) and *Can Our Cities Survive?* (1943) have been issued under his supervision.

As a counselor of the Kunsthaus at Zurich, it was possible for him to arrange in the early 1930's the first over-all shows of such artists as Picasso, Juan Gris, Fernand Geger, and Hans Arp. In 1938–1939, Dr. Giedion was the Charles Eliot Norton professor at Harvard, and from 1942–1945, he was a visiting professor at Yale. Since 1946 he has been at the Federal Institute of Technology at Zurich. His works best known in the United States are *Space, Time and Architecture,* and *Mechanization Takes Command.* Another book, *A Decade of New Architecture,* is now in preparation and will be published in Zurich this spring.

Hunsaker and McAdams Honored

NEW honors came recently to two well-known M.I.T. professors: one in the Department of Aeronautical Engineering, and the other in the Department of Chemical Engineering, both of whom have served the Institute for many years.

President Truman has appointed Jerome C. Hunsaker, '12, Head of the Department of Aeronautical Engineering, to serve on the National Advisory Committee for Aeronautics for a five-year term, expiring December 1, 1954. Dr. Hunsaker's record of public service, particularly in fields related to aviation, already includes service as chairman of the N.A.C.A., but the recent appointment assures his services for another half decade.

On December 6, 1949, Professor William H. McAdams, '17, of the Department of Chemical Engineering, was presented the William H. Walker Award by the American Institute of Chemical Engineers for his work on heat transfer. The Walker Award, named for the late William H. Walker, who was also a pro-

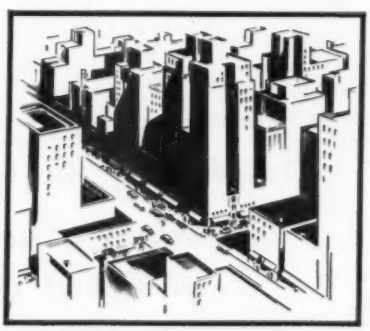
(*Continued on page 216*)

BUSINESS IN MOTION

To our Colleagues in American Business . . .

Because everybody spends a lot of time indoors, under a roof of one kind or another, the building industry has always been of prime interest to Revere. There are two reasons for this concern. One is the obvious consideration — a good, weather-tight, long-lasting building should contain adequate amounts of sheet copper in the appropriate places. The other is our feeling that, as a leading producer of sheet copper, we have an obligation to the public to see that there is an understanding of the economy and satisfaction obtained through the correct use of this metal for waterproofing.

Hence Revere some years ago embarked upon an extensive program aimed at developing the engineering principles, specifications and designs for successful application of sheet copper to all types of buildings. The information thus obtained has been freely published for all to follow, with assurance of lasting protection, whether for a home or a hospital, an office building, hotel or factory. Though anybody's copper can be used according to these specifications and designs, naturally Revere hopes it will be Revere copper, and indeed we are getting our share of the business. It is a great satisfaction to us not only to sell the copper, but to know that it is being applied in such a way as to give economical, enduring protection. This is especially important in these days of high labor costs, which make repairs due to the use of inferior materials or improper installation cost so much more than the price of good materials and workmanship, if used in the first place.



Now Revere has expanded its service to the building trades by offering solid copper flashing for masonry construction. The flashing is of chief interest to those designing and building large commercial structures, though of course it is also applicable to the private homes built of brick and stone. There is now available thru-wall flashing for economical and enduring protection against seepage and leaks at copings, parapets, belt courses, sills, spandrel beam facings and similar masonry applications. There is a reglet and reglet insert, also of solid copper, for waterproofing spandrels at costs comparable with or less than mopped-on waterproofing. There is vertical rib siding for use on high parapet walls, penthouses, and so on. All these items are pre-formed, and the simple directions for their use can be easily followed by any contractor, builder, or sheet metal worker. These new Revere Copper Products are available through sheet metal distributors throughout the country.

Though we have given these new items the widest possible publicity, we realize that in this vast country it is unlikely that absolutely everybody concerned will learn immediately about them and how much they can add to true economy. It takes time for news to get around. This time-lag is a problem for every company offering a new service or product. Recently we saw an advertisement of an important industrial material (felt) in which it was suggested: "Write us what you make, and benefit by our constructive ideas." That is good advice. Revere therefore recommends that no matter what you buy, whether metals or felt, chemicals or plastics, building materials or containers, you give your suppliers the opportunity to collaborate with you on the selection and application of new as well as old materials.

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THE INSTITUTE GAZETTE

(*Continued from page 214*)

fessor of Chemical Engineering at M.I.T., has been given since 1936 for distinctive contributions to literature of chemical engineering. Professor McAdams is the third from M.I.T. to be given this honor. The others were Thomas K. Sherwood, '24, Dean of Engineering, award winner in 1941, and Professor Hoyt C. Hottel, '24, Director of Fuels Research Laboratory, who was given the medal in 1945. Professor McAdams has done much important research and consulting work in heat transfer and has pioneered many recent developments. When the American Institute of Chemical Engineers convened in December for their annual meeting, Professor McAdams reviewed fundamentals of the various types of heat transfer.

F. J. Curtis, Vice-president of Monsanto Chemical Company and retiring President of the professorial group of chemical engineers, made the presentation to Professor McAdams whom he cited "for his long series of authoritative publications in the field of heat transmission, represented in recent publications by the papers: 'Measurement of Recovery Factors and Coefficients of Heat Transfer in a Tube for Subsonic Flow of Air,' and 'Heat Transfer from Single Horizontal Wires to Boiling Water.'"

Study for Executives

FOURTEEN young business executives, largest group in the 13-year history of the executive development program at M.I.T., will be awarded Sloan Fellowships in 1950. Awarded to outstanding young executives in a nationwide competition, these fellowships cover a year of advanced study in economics and business administration at the Institute and are aimed at preparing men for higher executive responsibility.

The fellows will be drawn from both large and small companies in various types of industry throughout the country. The winners of the fellowships will participate in a special program consisting of seminars, classes, and field investigations aimed not only at increasing technical managerial skill, but also at deepening their understanding of the social and economic implications of their work. They will study in the Institute's Departments of Business and Engineering Administration, and Economics and Social Science, and will have an opportunity to conduct a special investigation in some selected field of industrial activity, such as finance, production, distribution, or labor relations.

Applications for the awards must be made by February 24. Recipients will be selected on a competitive basis by M.I.T. after consideration of the applicants' records and references, and consultation with their

(*Concluded on page 218*)

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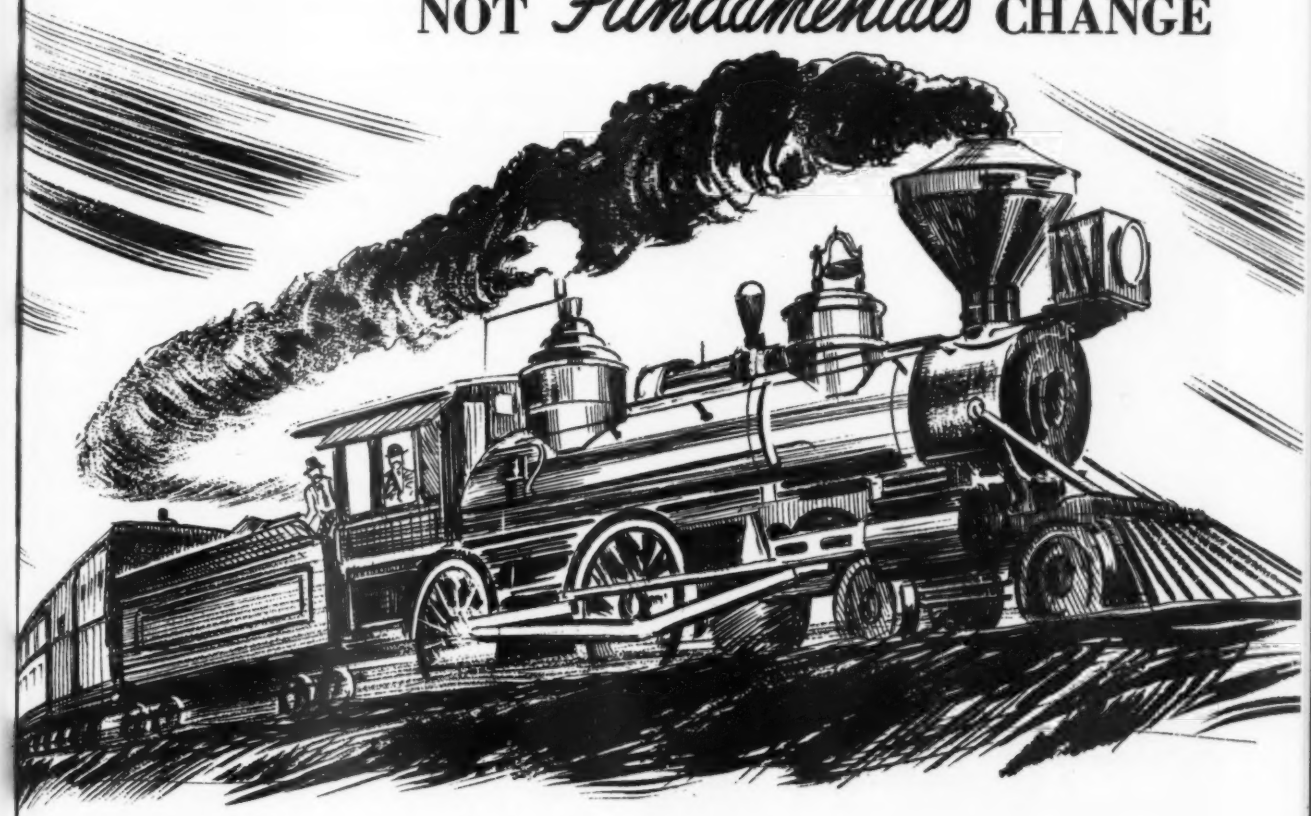
THROUGH THE YEARS *Details* NOT *Fundamentals* CHANGE



The evolution of fuel into energy into self-propulsion is as basic to giant modern locomotives as it was to the picturesque old wood burners which scattered smoke and sparks across the countryside. For details, not fundamentals, change.

And during the years since the little wood burner first set the pattern for today's technological behemoths, Boston Manufacturers Mutual Fire Insurance Company and Mutual Boiler Insurance Company of Boston have demonstrated the immutable value of the fundamental principles upon which they were founded.

Their basic operating principle of fire and accident ***prevention*** through laboratory research and plant ***inspection*** is as sound today as it was when both companies were organized by manufacturers who had banded together for mutual protection against their common enemy: Accidental Loss.

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THE INSTITUTE GAZETTE

(*Concluded from page 216*)

employers. Awards range up to $2700 for single men, and up to $3700 for those who are married. Fellows will be in residence at the Institute in Cambridge from June 9, 1950, to June 10, 1951. Applicants must be between the ages of 30 and 35 and have at least five years' industrial experience, part of which must be in an executive capacity.

In discussing qualifications of successful candidates, Gerald B. Tallman, Associate Professor of Marketing in the Department of Business and Engineering Administration, who directs the program, said: "Managerial ability, seasoned intellectual capacity and a sensitivity to the social and civic implications of industry, as well as a high potential for industrial leadership are the primary qualities upon which selection will be made. In addition, candidates must be graduates with good academic records from an accredited college or university. A majority will be graduates in science or engineering. The men will be on leave-of-absence from their companies and must have the enthusiastic support of their employers."

The original Sloan Foundation grant for these fellowships was made in 1938 as part of a program to promote "the increase and diffusion of economic knowledge." There are 47 past recipients of M.I.T. Sloan Fellowships, among whom are 10 current fellows who will complete their studies in June, 1950. As evidence of the program's breadth of coverage, the current group represents such varied companies as Corning Glass Works, Pratt and Whitney, Johnson and Johnson, Ford Motor Company, Illinois Bell Telephone, Richmond Engineering, Goodyear, National Gypsum, Radio Corporation of America, and Standard Oil Company of California.

Excellence in Graphic Arts

For the sponsorship of an outstanding product of American commercial printing, a Certificate of Excellence has been awarded to the School of Architecture and Planning at M.I.T., by the American Institute of Graphic Arts.

The award, made in connection with the 1949 Printing for Commerce Exhibition, is for a brochure entitled "Education of Architects and City Planners" designed by Professor Gyorgy Kepes of the School of Architecture; text for the brochure was prepared by Henry-Russell Hitchcock, lecturer in architectural history.

Crew Coach Honored

James B. McMillin, varsity crew coach at the Institute, was elected president of the Rowing Coaches Organization of America at its recent annual meeting in New York. In this post, Mr. McMillin succeeds Harrison Sanford of Cornell University.

Beginning his 10th season as head of the Engineers' crews, Coach McMillin came to M.I.T. in 1939 after captaining a championship University of Washington crew in Seattle.

THE TREND OF AFFAIRS

(*Continued from page 202*)

Chemical analysis has shown that it consists essentially of oxides of silicon, iron, aluminum, and magnesium. An analysis of an exfoliated sample gave the following results (rounded off to full per cent):

SiO_2	39	per cent
Fe_2O_3	11	" "
Al_2O_3	14	" "
$Ma_2O + K_2O$	5	" "
MgO	22	" "
CaO	1	" "
TiO_2	1	" "
Moisture and various impurities	7	" "
	100	" "

The outstanding characteristic of expanded vermiculite is that of an exceptional insulator, thermal as well as electrical, but especially thermal. This was interesting but unimportant because so little vermiculite could be had at any one time that, at best, the amount would have been sufficient only for laboratory use. But some 20 years ago a very large deposit of vermiculite was discovered near Libby, Mont. By 1946 the *Minerals Yearbook* of the Bureau of Mines reported production of this material from seven states: Colorado, Montana, Nevada, North Carolina, South Carolina, Texas, and Wyoming. Whereas the average annual production between 1935–1939 was 18,000 tons, by 1946 annual production of vermiculite had risen to 86,000 tons.

In the course of preliminary research it was found that expanded vermiculite was not only a very poor conductor of heat but that it was also capable of absorbing large amounts of heat. Furthermore, it did not change itself, even when heated to a high temperature for a long time. In addition to all this, it has a very low specific gravity, weighing about six pounds per cubic foot. It could be used loose as a filler in wall spaces (as rock wool is) or in lieu of sand in concrete, or as an admixture to plaster. It is also used in insulating refractory brick, in lightweight and fireproof structural units, in non-load-bearing partition tile, and as a packing material around glass acid bottles and carboys.

The main reason for using expanded vermiculite in concrete is, of course, the fireproofing and fire-resisting feature, but there is a very considerable weight reduction among the by-products. One example is the 35-story Mercantile National Bank Building in Dallas, Texas. It has been estimated that the weight of the concrete for this building would have been 42,124,523 pounds if the customary cement-sand mixture had been used. The mixture of cement and expanded vermiculite actually used weighed 10,855,870 pounds. This reduction in weight reduced the amount of structural steel in turn: 4,400 tons of steel were actually used. The estimate for conventional construction was 6,280 tons.

Demonstrations of its fire-resisting qualities are especially impressive. A one-inch slab of cement-ver-

(*Concluded on page 220*)

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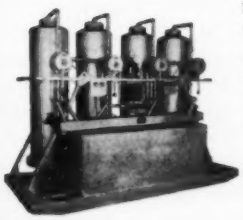

Chances are that if you need high-test mineral-free water Barnstead Demineralizers can save you money. For Barnstead Demineralizers produce water of far higher purity at lower cost with a minimum of maintenance. Whether you need 5 gallons an hour or 1000 . . . there is a Barnstead Demineralizer to fit your requirements *exactly*. And a Barnstead engineer can "plot" the course of Pure Water *precisely*. Ask for Barnstead detailed recommendations. No obligation.

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Constant Current Regulators *(Static Type)*

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THE TREND OF AFFAIRS

(*Concluded from page 219*)

miculite concrete was placed on a sheet of paper, and a two-pound magnesium incendiary bomb was permitted to burn itself out on top of the slab of concrete. At the end of the experiment the paper under the concrete slab was found to be uncharred. Another experiment consisted of a simulated fire in a building. The floor of the upper story consisted of two inches of vermiculite concrete. This was supported by a steel beam, and under the steel beam there was a ceiling consisting of a one-inch-thick slab of vermiculite plaster. That ceiling was heated to 2,000 degrees F., corresponding to an unusually hot fire in the lower story, and hot enough to weaken structural steel dangerously. This heating was continued for a period of four hours, far beyond the time a real fire in any office building would be likely to last. At the end of that period, the temperature of the floor in the upper story was measured: it was 203 degrees F. which is not quite high enough to boil water.

Standard Frequency and Time

For many years time and standard frequency signals, accurate to within a few parts in one hundred million, have been broadcast from Station WWV, operated by the National Bureau of Standards. The usefulness of such transmissions has been increased with a change of transmitting schedule, effective January 1. Standard time signals, announced both in code and voice every five minutes, are now being transmitted on carrier frequencies of precisely 2.5, 5, 10, 15, 20, 25, 30, and 35 megacycles per second and may be received on an ordinary short-wave receiver. Each carrier is modulated by standard frequency tones of 440 and 600 cycles per second, transmitted in alternative five-minute intervals. Short pulses, heard as faint clicks, mark second intervals.

NEXT WAR'S WEAPON

(*Continued from page 204*)

Air-to-air rockets were also used by the Germans in World War II against Allied bomber formations. These weapons will come into prominence as combat is begun at greater ranges and it is entirely possible that the future will bring forth a heavily armored destroyer, fitted with rocket-launching turrets. The rockets could be aimed by radar and detonated by proximity fuses when they reached their targets. The larger projectiles might even be guided, either from the launching airplane or from the ground. These destroyers, however, will undoubtedly represent a transitional stage in warfare and will be rapidly superseded.

By employing short-range rockets, the "Jato," or jet-assisted take-off, also has great practical importance, for it permits a considerable increase in take-off weight, and hence performance, and it can be used

to reduce the length of the runway needed by an aircraft to become air borne.

However, it is the medium-range rocket, which was beginning to appear during the final stages of World War II, that holds much promise in revolutionizing air combat as we know it today. This type is exemplified by the medium-range rocket interceptor, of which both piloted and guided versions were under intensive development by the Germans at the end of hostilities in Europe.

One of the piloted machines, the *Me-163*, actually became operational while a second, the *Natter*, was undergoing short test flights when the war ended. Both were manned rockets of a very short endurance (five minutes under full power to be exact) but they had phenomenal rates of climb. The *Me-163*, for example, could get up to 40,000 feet in three minutes, while the *Natter* could get that high in little over one minute. Intensive future development in this field undoubtedly will result in the conventional fighter being superseded by this type of aircraft. Their high rate of climb would enable them to stay on the ground until the enemy bombers were only a few miles away. They would then go up, almost vertically, into action, break off the engagement, and return to the ground. If they launched rocket projectiles into the bomber formations, the latter would find it very difficult to carry out the assigned mission. The defense would have to be accomplished either by having flying destroyers in the formations, or by the use of such enormous speed that interception was impossible. This, in effect, means the replacement of the bomber by the long-range rocket, and at this point the pilot begins to disappear from the picture.

Science has proven that the human body can withstand only limited accelerations, can respond to only a few stimuli at a time, and has comparatively slow reactions. The speed of attack in air warfare is steadily increasing and the 3,400 miles per hour of the *A-4* is only the beginning. Man can never hope to fight against such speeds. Skill, courage, and resolution will not suffice and the time will come when only machines can fight machines.

German War Research

At the close of World War II, the Germans were discovered to have been working desperately on a large number of guided rockets, such as the *Rheintochter*, *Schmetterling*, and *Wasserfall*. Some of these rockets had been tested, and claims of one contact in four had been made with experimental models. These missiles, made with experimental models, were to be controlled from the ground by radio and directed into the bomber formations where they would "home in" on their targets by radar or infrared detectors. They would be capable of very high speeds – up to the speed of sound – and when they were perfected, it is hard to see how conventional bombers could successfully defend themselves against attacks from guided missiles. Elaborate countermeasures could be tried, similar to those used in the radar war, but it is not feasible or desirable to jam the entire radio spectrum. Automatic homing rockets might be

(*Continued on page 222*)

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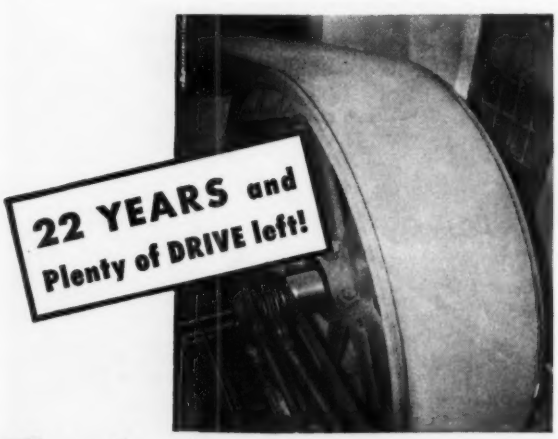

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NEXT WAR'S WEAPON

(*Continued from page 221*)

rendered harmless for awhile, but there would not be any effective defense against a ground-controlled projectile carrying television and homing in on the hundreds of kilowatts of heat thrown out by the bomber's engines. Such rockets have already been developed and do not represent any great advance in existing technique.

These weapons may mark the end of the man-carrying fight but not necessarily the end of the fighter pilot who represents a complexity of skills difficult to replace by machinery. There have already been several examples of missions largely controlled from the ground. "Oboe" bombing and fighter sweeps, radar-controlled, are two examples. The remote-controlled fighter, operated by a pilot many miles away, is therefore a logical development.

Guided missiles will also be a boon to naval operations and may well replace fighter aircraft for defensive purposes in the very near future. The large vulnerable carrier will no longer be required to provide fighter cover as its primary mission. Then, too, the necessity of getting aircraft safely back down on the carrier, after an action, will be eliminated, thus giving the fleet greater freedom of action. To a large extent, guided rockets could replace heavy guns for long-range engagements and thereby provide a saving of weight of many thousands of tons in the case of capital ships.

The guided rocket appears to be the only conceivable defense against the long-range rocket bomb. This type was developed by increasing the speed of the rocket sufficiently to be given nearly antipodal ranges, although this is done at the expense of very small pay loads. The German-type *A-4* had a maximum speed of 3,400 miles per hour and a range of 220 miles. The Germans planned to increase this range to 3,000 miles by giving the *A-4* wings and launching it from a much larger booster rocket, the *A-10*, which would, if the work had been completed, have weighed about 85 tons. The important point in connection with the long-range rocket is that its step-rocket principle provides one method of circumventing the velocity pay-load view.

Rocket Defense

Even today, once they have been fired, there is no proven defense against guided rockets, and their launching sites are much less vulnerable to enemy attack than airfields. A preliminary analysis reveals that, with conventional explosives, rockets may be more economical than bombers for ranges up to about 400 miles. As compared with heavy-bomber operations, the enormous saving in man power required for a rocket offensive is also an important factor, as well as the fact that rockets can be mass produced at very little cost.

Today it requires a rocket weighing about 100 tons to deliver a pay load of one ton at a distance of 3,000 miles, inasmuch as 70 per cent of this weight is in fuel. Atomic bombs weigh only a few hundred pounds and

(*Continued on page 224*)

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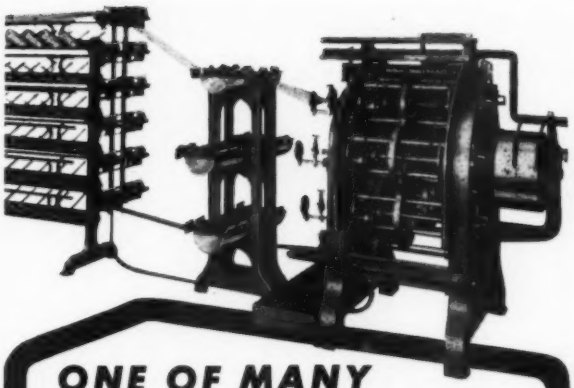

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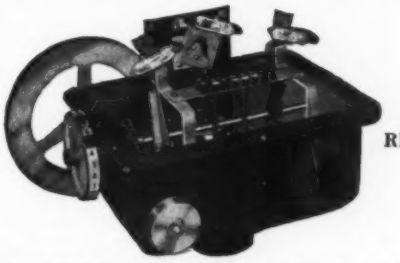

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NEXT WAR'S WEAPON

(*Continued from page 222*)

need never be much larger, though their efficiency, of course, will increase. These two facts seem to point out the final end of the very heavy bomber.

It is true that the main objection to the rocket as a long-range weapon is its inaccuracy; but this defect will certainly be overcome in time by the use of target-locating devices, radio lattices (fixes), or television. It would be virtually impossible to jam a rocket controlled by a locked microwave beam from a high-altitude relay airplane several hundred miles away, especially since the radio control might be required only for a very few seconds when the projectile was nearing its target. It will also be possible to develop entirely self-contained controls similar to those used in the later *A-4's* fired against London. Rockets would contain course integrators which could be set for any required destination and which could not be affected by any external signal. Once launched, only an actual collision could deflect such a projectile from its target.

As has been mentioned before, no complete defense is possible against such weapons. The only defense of any kind would be the guided rocket. Visualize, for a moment, the development of small machines capable of accelerations of 100 or more times that due to gravity, and homing in on radio, radar, or even local gravity fields. Such machines would be equipped with various means of identification – (Interrogation: friend or foe) – to prevent them from attacking each other. The possibilities here are endless; for, among other things, science might inject suitable metals into the blast coupled with spectrum analyzers for interrogation. However, even such highly developed defensive machines would be hard put to intercept, in a matter of seconds, projectiles traveling 3,000 miles per hour or more.

Rockets and the Atom Bomb

Many engineers and scientists have advocated the use of the rocket as an ideal means of delivering atomic explosives. This may soon prove to be the only method that can be used without destroying the attacker. Another important advantage is that the enormous impact velocity of the rocket greatly simplifies the detonation problem if a ground burst is required. The subcritical masses have only to be placed on the axial line and they will be united at a speed which will prevent premature detonation and make unnecessary the complicated gun arrangements in the present atomic bombs.

If it becomes possible to build an atomically propelled rocket with motors of no more than the efficiency of the Hiroshima bomb, roughly 0.1 per cent, the resulting jet velocities would be many millions of miles an hour, and the theoretical limit would be the velocity of propagation of light itself. Even though such speeds would be out of the question inside the atmosphere, it would be a comparatively simple matter to design rockets flying under continuous thrust at very high accelerations along constantly randomed paths. The interception of these rockets by any ma-

(*Concluded on page 226*)

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NEXT WAR'S WEAPON

(*Concluded from page 224*)

terial projectile would be virtually impossible, since, even if they could be detected, their destinations could not be foreseen until it was too late.

The Germans actually had one type of long-range piloted rocket in mind at the end of World War II, but this type has too few military advantages. For one thing, it does not provide adequately for the safe return of the crew. Such rockets might be valuable for reconnaissance, but even here they would eventually be superseded by the guided rocket carrying television equipment.

A true rocket bomber, a manned rocket delivering explosive loads and capable of returning to its base, appears to have no advantages over the long-range guided rocket, and it has some disadvantages, particularly vulnerability and low performance, since it has to carry a much greater weight of fuel as well as the equipment needed by the crew. However, General Henry H. Arnold, in his report to the Secretary of War, has suggested that such machines would be required to launch rockets from unexpected quarters if the defense against long-range projectiles became too effective. These machines would be true space ships, traveling in trajectories outside the atmosphere. This argument does not seem to hold, since guided rockets could be designed to follow courses at least as tortuous as those manned machines and at much greater speeds. An interesting point to note in connection with these machines is that they could not employ bombs in the ordinary sense of the word, since any part of the load would share the ship's orbital motion and so would not be capable of falling back to earth.

A rocket which attains a speed of five miles a second above the atmosphere would never return to earth but would continue to circle it forever in an astronomical orbit. At a higher speed, for example, seven miles a second, the rocket would escape from the earth's gravitational field completely and recede into interstellar space.

While chemical fuels are used, these velocities can only be achieved by step rockets of very small pay load; such machines are likely to be of scientific value only. The advent of the atomic drive would, however, change the picture completely, for, if conversion efficiencies of 0.1 per cent were achieved, fuel loads of only a few per cent would be ample for journeys to be nearer planets. This is mentioned only to show the spectacular possibilities which will be an immediate outcome of any harnessing of atomic power to rocket propulsion. When that time comes, and it is not too far away, vistas will be opened before which our present imagination falters. The least of the achievements one may expect to see is the establishment of stations in closed orbits at heights of 1,000 miles or more, circling the worlds in periods of a few hours like artificial moons. The Germans were actually planning such stations and such an arrangement does present an attractive solution to the problem for world surveillance and control.

These futuristic word pictures may appear to be so fantastic as to be unworthy of serious consideration, but they are the logical, inevitable outcome of one aspect of atomic energy and, as such, cannot be ignored in rocket development.

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ATOM-BOMB WORLD

(*Continued from page 206*)

2. That the General Assembly be reconstituted as the legislative branch of the world government in which the citizens of the member states are represented on an equitable basis.
3. That the General Assembly, in addition to its present functions shall have the power:

(a) to make laws prohibiting, or otherwise controlling, weapons of mass destruction and, so far as necessary for that purpose, regulating the uses of atomic energy;
(b) to make laws providing for such inspection as is necessary or appropriate to the execution of the foregoing powers;
(c) to provide for appropriate civil and criminal sanctions for the laws enacted pursuant to the foregoing powers;
(d) to provide and maintain such police forces as are necessary for law enforcement.

4. That independent judicial tribunals be created with jurisdiction over cases and controversies arising under laws enacted by the General Assembly or involving questions concerning the interpretation of the charter of the United Nations.
5. That a Bill of Rights be designed for the protection of persons affected by laws enacted by the General Assembly.
6. That the Security Council be reconstituted as the executive branch of the world government with the power:

(a) to administer and insure the enforcement of the laws; and
(b) under the direction of the General Assembly, to perform its present functions as defined in the charter.

7. That the powers not delegated to the General Assembly be reserved to the member states.

These proposals and objectives represent the essence of the best thought upon the subject, and are, in fact, the proposals and objectives drawn up by the Rollins College Conference on World Government. They represent the minimum requirements necessary for the creation of a world government capable of averting the catastrophe of another war in the atomic era.

Congress Awaits

Since the first reaction to the consequences of the atom bomb has gradually died down and been replaced by a concentration on a possible war with Russia, the situation of mankind has become more dangerous than ever. Congress is waiting for the people to tell it what to do. If we raise our voices, we shall be heard. If all of us join our voices together, what we have to say will prevail. There is very little time left. Here is what we can do:

1. We can make our congressmen aware of the reasons for the necessity of world government, and can urge them to make their influence felt on the subject.
2. We can urge the United Nations to adopt the above proposals.
3. We can support all organizations having world government as their objective.
4. We can organize a world-government group in our neighborhoods if one does not already exist there.
5. World government implies co-operation, not competition, between the peoples of the earth. One of the things we can do immediately is to cast our vote for peace by beginning to live co-operatively. The only defense against the atom bomb is the moral aspiration of people to live in peace with

(*Concluded on page 230*)

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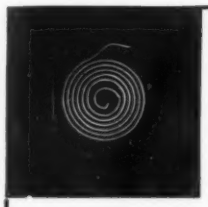

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ATOM-BOMB WORLD

(*Concluded from page 228*)

one another in a united world under a common world government.

Freed from the menace of war, atomic energy can be, for all of us, in all nations, the great cohesive force which makes one world possible. To assist us toward realizing this aim, we have today at our disposal the philosophy, firmly based in science and in religious teaching, of the unity of all mankind; a philosophy which creates emotional force as well as intellectual conviction; a philosophy which creates the consciousness of a common purpose in mankind, which at once establishes the principle of the right to cultural self-determination and the international co-operation of all mankind.

The scientists who created the atom bomb have themselves set us the pattern by means of which this purpose can be realized; for, into the creation of the atom bomb went the genius of many nations. The free and untrammeled co-operative labors of the scientists of the whole world contributed to the discovery of atomic energy. Without world co-operation of scientists, that discovery would have been quite impossible. We knew that atomic energy was a real and not an imaginary thing before we discovered how to release it. We have now to conquer it. Similarly, scientists know that mankind is one, and are in process of discovering the means of releasing those energies which will make all the world believe it. But the task is far more difficult than that of the nuclear physicist, far more difficult and far more complex. Thousands of us will have to be engaged upon a thousand different fronts in order to solve our problem; and, we can solve it only as the nuclear physicists solved theirs: by co-operation. In co-operation, and in unity on a world scale, lie the strength which will make humanity safe for mankind. Now is the time for clear and careful thought implemented by resolute action. Unless we act with intelligence and resoluteness now, we may never have another chance.

THE DELAYED INVENTION

(*Concluded from page 210*)

do the same job, with a marine biological station as an adjunct.

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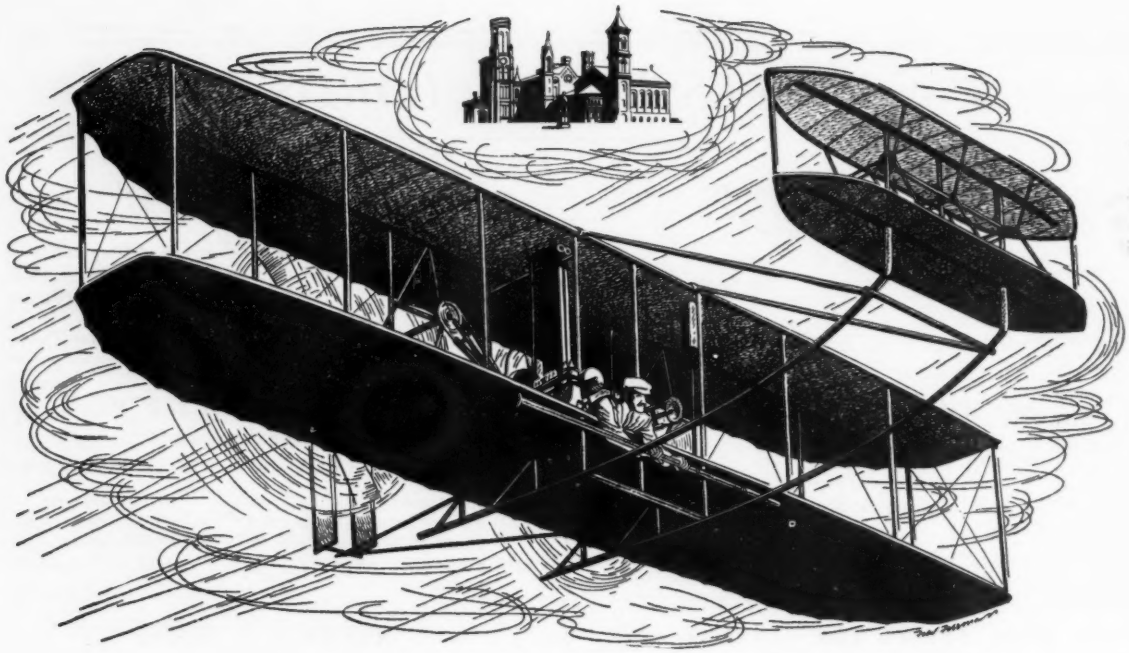

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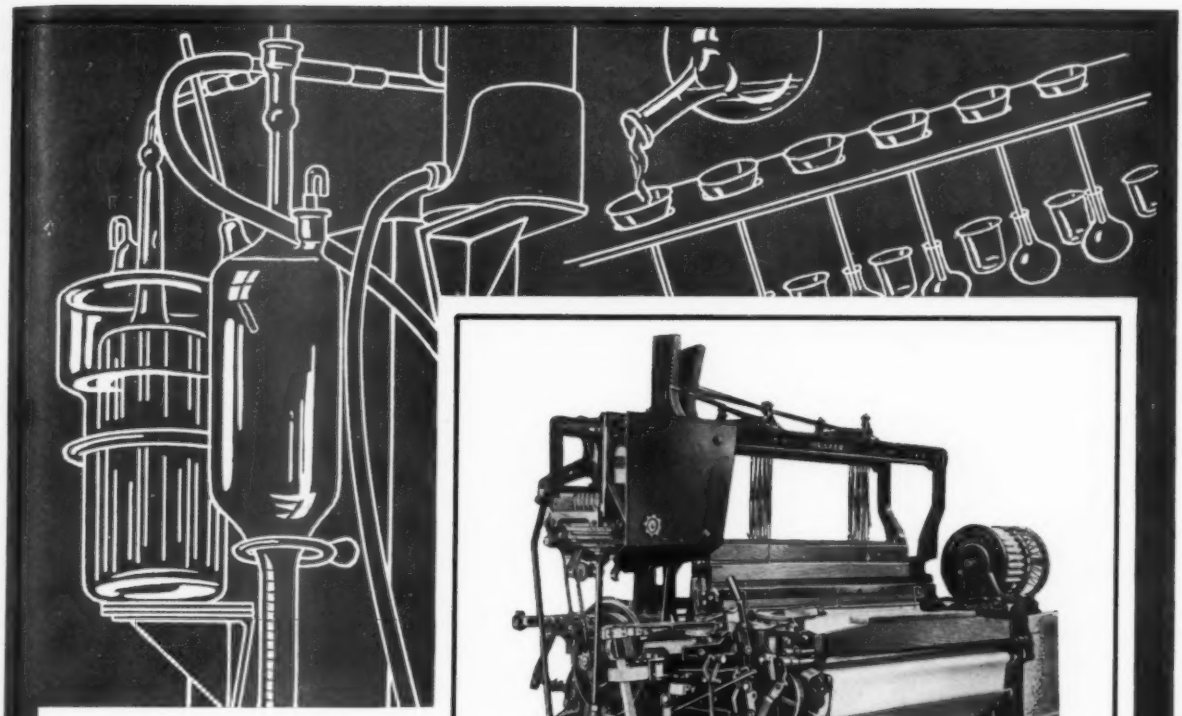

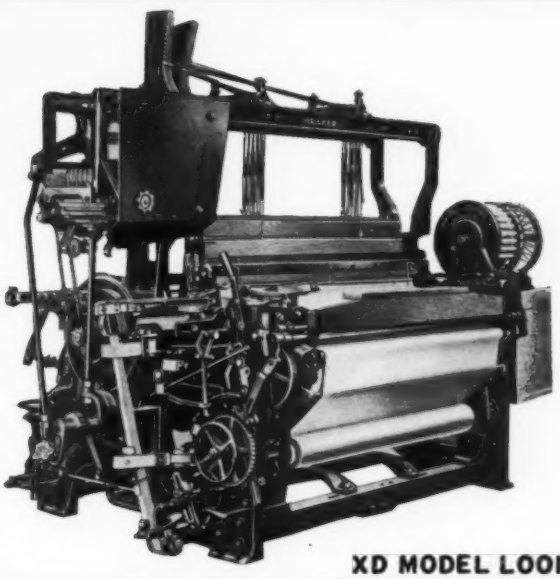

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